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ABSTRACT

Investigations in Natural Science is a program in secondary school biology, chemistry, and physics based upon the description of science as a quest for knowledge, not the knowledge itself. This student manual contains the 18 biology investigations. These investigations focus on concepts related to: organisms; classification; populations; producers; food chains; ecosystems; cells; cell transport; circulation; calories; digestion; breathing; responses; locomotion; cell division; reproduction; inheritance; and homeostasis. Each investigation (which is accompanied by a student reading, with questions to answer) includes activities related to the three learning cycle components, namely, exploration, conceptual invention (the idea), and expansion of the idea. (JN)

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INVESTIGATIONS IN NATURAL SCIENCE

BIOLOGY

Student Investigations and Readings

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CONTENTS

INVESTIGATION 1: ORGANISMS	1
Reading: Supplying the Needs	5
INVESTIGATION 2: CLASSIFICATION	9
Reading: Classifying Organisms	13
INVESTIGATION 3: POPULATIONS	20
Reading: Limiting Factors Controlling Animal Populations	26
INVESTIGATION 4: PRODUCERS	30
Reading: Death of a Producer	34
INVESTIGATION 5: FOOD CHAINS	38
Reading: Producers and Consumers	41
INVESTIGATION 6: ECOSYSTEM	46
Reading: Ecosystems in North America	50
INVESTIGATION 7: CELLS	56
Reading: Units of Life	63
INVESTIGATION 8: CELL TRANSPORT	66
Reading: The Cell Membrane	71
INVESTIGATION 9: CIRCULATION	75
Reading: Problems of the Heart	84
INVESTIGATION 10: CALORIES	87
Reading: Food, Glorious Food	92
INVESTIGATION 11: DIGESTION	96
Reading: Why Doesn't the Digestive System Digest Itself?	99
INVESTIGATION 12: BREATHING	102
Reading: Keeping in Shape	107
INVESTIGATION 13: RESPONSES	111
Reading: Animal Senses	118
INVESTIGATION 14: LOCOMOTION	123
Reading: Movement	127
INVESTIGATION 15: CELL DIVISION	131
Reading: Carrots, Cloning and Cancer	135
INVESTIGATION 16: REPRODUCTION	140
Reading: Common Birth Defects	141
INVESTIGATION 17: INHERITANCE	144
Reading: The Genetic Chance	148
INVESTIGATION 18: HOMEOSTASIS	153
Reading: The Heat is On	156

INVESTIGATION #1: ORGANISM

Name _____
Section _____ Date _____

INTRODUCTION

How carefully do you observe the things in your environment? There are many interesting things in nature that you can observe. Some things are living, while others are not living. What differences have you observed between living and non-living things?

EXPLORATION

Grab Bag

In Table 1-1 add the descriptions (do not name the object) given by your group members

Table 1-1

Student	Object Number	Description

INVESTIGATION #1: ORGANISMS

Name _____
Section _____ Date _____

EXPLORATION

Many Things

There are different things placed around the room for each of you to observe. As directed by your teacher, carefully observe and describe the characteristics that make the things at each station living or non-living.

Table 1-2

[illegible]

INVESTIGATION # 1: ORGANISM

Name _____
Section _____ Date _____

THE IDEA

Table 1-3

Key Characteristics of Living Things	Evidence Observed

1. List three important differences between the non-living object shown and a living thing.
2. How can you distinguish one living thing from another?
3. What idea do the data allow you to state?

INVESTIGATION # 1: ORGANISM

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Cold Water

1. Set up a container of aquarium water as directed by your teacher. Record the initial temperature of the water: _____° C.
2. Place a goldfish into container. Allow 2-3 minutes for the fish to calm down.
3. Count the number of times the mouth of the fish opens for one minute. Wait one minute, then count the number of mouth openings occurring in the next minute. Record these data on Table 1-4.

Table 1-4

	Number of Mouth Openings in Aquarium Water at:		
	Initial Temperature	Cold Temperature	Changes in Number of Mouth Openings
Minute One			
Minute Two			
Average			

4. Set the container with fish in an ice bath until the temperature of the aquarium water is 5° C lower than the initial temperature. Count the mouth openings for one minute. Wait one minute, then count the number of mouth openings in the next minute. Record these data on Table 1-4.
5. What effects did the change in the temperature have on the behavior of the fish?
6. What effect did the change in temperature have on the number of mouth openings per minute of the fish?
7. What might happen to the fish if the temperature change went beyond a certain limit?

INVESTIGATION #1: ORGANISMS

EXPANSION OF THE IDEA

Readings: Supplying the Needs

As we have seen in Investigation 1, organisms are affected by changes in the environment. We have called these changing factors environmental variables. "Environmental" refers to the external or outside forces which affect the life and growth of organisms. The word "Variable" comes from the smaller word "vary" which means "to change". Environmental variables which can fluctuate a great deal from day to day or season to season include light, temperature, and moisture. Can you think of any others?

All organisms can tolerate some increase or decrease in these factors. If the change is too drastic, many will not survive. Drastic changes in one of these environmental variables may exceed the ability of an organism to tolerate it. If this happens, the factor will limit the number of organisms able to survive. It has become a "limiting factor."

In the activity "Cold Water" you observed that the ability of fish to breathe was affected by the variable, temperature. The fish were seen to tolerate a range of temperatures between a normal temperature and a lower limit.

What might happen when an environmental factor becomes extreme, for example, when the temperature becomes too high or too low? The organisms must adapt to the change or die.

So far we have studied a single environmental variable in the laboratory. However, many variables are operating in the natural environment.

Three changeable factors which supply the needs of organisms are food, water, and cover.

FOOD is necessary for any form of life. The greater the variety of food in an area, the more kinds of organisms which can make it their home.

WATER is essential to organisms, but the kind and amount of water needed varies with the kind of organism. Some animals require drinking water, but others can get their water from the food they eat. Water is also important because it supports the vegetation needed for food and cover. And, of course, water is absolutely necessary for fish and other aquatic organisms.

COVER can be any material that gives animals a place to hide from enemies or a place that offers shelter from the weather. It might be a patch of aquatic plants for a sunfish, a brushpile or thicket for a rabbit or a forest for a herd of deer.

Good protective cover is need throughout the year, although the requirements may change with the seasons. For example, grass and weeds are adequate for summer nesting cover for quail, but when winter arrives, they must find cover that gives protection from the weather. Winter is the hardest time of year for all animals, and the presence of dense trees for squirrels and raccoons, brushpiles for rabbits and dense thickets for quail and turkey can be the major factor which determines their survival.

The same vegetation often serves as both food and cover for wildlife. A variety of cover is important because different plants produce food in different seasons. In this way, food is available all year long.

Within the basic requirements, each organism has particular needs. Obviously, food for a bass would not be food for a snail, and cover for a weasel would not be suitable for a deer. But, sometimes an animal's particular needs are not so obvious. American bison, for example, are especially fond of a grass called little bluestem. When an area has been grazed too heavily, this grass may die out and be replaced by grama and other grasses. When this happens, bison do very poorly, even though there seems to be plenty of grass. It is the wildlife manager's job to understand the subtle needs of an individual type of organism. An area which supplies everything an organism needs to survive is called its HABITAT.

A cottontail rabbit facing the rigors of winter can survive only if it has the benefits of good habitat. Good habitat includes vegetation and other elements which provide the essentials of food, water, and cover. While man can modify the environment to make sure it provides these things, the cottontail cannot. If any of these essential needs are disturbed or removed, the cottontail will probably die.

Locating these three basic elements within a habitat is of utmost importance. Sometimes, although an animal's habitat needs are present, they are not properly located for the animal's use. If water is too far from food and cover or bedding cover is too far from escape cover, the habitat is not suitable for wildlife. Each organism has its own measure of distance. What might be too far for a raccoon or squirrel might not be too distant for a deer or mourning dove.

If, in your community, we moved all bedrooms to the south edge of town, all grocery stores to the next county to the east and the water supply ten miles west, how many people could live there? This is how it works for wildlife as well.

Many times, you can guess what kind of habitat an animal lives in by looking at the animal's physical characteristics. For example, the webbed feet of the duck make it a safe bet it lives in a wetland environment. The eagle's sharp, curved claws suggest it hunts and kills other animals for food. The duck and the eagle are well adapted to utilize the resources available in their environment.

If a habitat is changed, an area may become less suitable for the organism already there and more inviting for other types of wildlife. For instance, clearcutting small areas of timber will eliminate squirrels, but may improve conditions for deer and quail. Damming a stream to create a reservoir can wipe out the habitat needed by smallmouth bass, but the newly formed lake will provide conditions favorable for ducks and the stocking of such open water organisms as crappie, walleye, striped bass and white bass. Changes in habitat alter the kinds and number of organisms in an area.

Many changes which man inflict upon the land may be damaging to all wildlife. Severe pollution, urban development, and certain farming or forestry practices which alter the habitat are common examples of things that make an area uninhabitable for wildlife. What is left for wildlife when land is bulldozed, concrete poured and bermuda grass planted for a new housing development? Wildlife habitat is lost, and this loss is the greatest threat to wildlife today. Maintaining a good habitat is the key to the future of wildlife. If suitable habitat is available, it will be occupied, but if the habitat is changed drastically, the wildlife will disappear.

A simple example illustrates the comparative importance of habitat to the continued existence of wildlife. Hunters may return to the same area year after year to hunt quail because guidelines set for hunters by modern game management insure some animals will be left to reproduce and reoccupy the habitat. By contrast, building a housing development offers no such guidelines. When construction crews move in and start bulldozing, the trees, shrubs and grasses that provide quail and other animals with food and shelter disappear. The animals, unable to move away, follow their habitat into oblivion.

This reading is taken in part from Critters and Concepts prepared by the Oklahoma Department of Wildlife Conservation.

INVESTIGATION #1: ORGANISM

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading: Supplying the Needs

1. What needs of an animal are supplied by vegetation?
2. What changes occur when a dam is built?
3. Describe the habitat in which a bird with the following foot adaptations might live. Be sure to include all factors of the habitat in your description.



4. Select one of the ways in which man changes wildlife habitat _____.
In what ways might this kind of change affect a cottontail rabbit?

INVESTIGATION #2: CLASSIFICATION

Name _____
Section _____ Date _____

INTRODUCTION

Many different organisms exist in the environment. How can these differences be used to group the types of organisms?

EXPLORATION

Observing Insects

1. Before the class activity:

COLLECTING: You will begin collecting several days before the classroom activity begins. Your teacher will suggest methods of capturing and transporting organisms to the classroom. Ask your teacher how to store the organisms you collect.

KILLING THE INSECT: The insects should be put in the kill jar provided by the teacher. Leave the insects in the kill jar until you are ready to mount them on pins.

PINNING THE INSECTS: Following the directions given to you by your teacher, mount the insects on the pins provided and pin them in the box provided for the class.

2. Carefully observe the specimen provided, divide them into two groups and record the observations (Table 2-1) you used to separate the insects.

Table 2-1

Group	Observable Characteristics
I	
II	

3. Observe the characteristics of the insects within each group. Divide Groups I and II into two subgroups each. Record your observations in Table 2-2.

Table 2-2

	Subgroup	Observations
Group I	IA	
	IB	
Group II	IIA	
	IIB	

INVESTIGATION #2: CLASSIFICATION

Name _____
Section _____ Date _____

THE IDEA

1. What characteristics did you observe that were common to all insects?

2. What characteristics did you observe that were different among the insects?

3. How did you use these similarities and differences to group the insects?

4. What idea do the data allow you to state?

INVESTIGATION #2: CLASSIFICATION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Classification of Organisms

Fill in Table 2-3 as directed by your teacher.

Table 2-3

Organism Name	Steps Followed	Common Name	Scientific Name

INVESTIGATION #2: CLASSIFICATION

EXPANSION OF THE IDEA

Reading: Classifying Organisms

During your explorations of the world around you, you have observed many organisms. Think of the variety of plants and animals you have seen. Even if you could identify hundreds of different organisms you would have observed only a very small percentage. Nearly a million different animals have been classified and almost 350,000 plants have been identified.

Cougar, mountain lion, panther, puma, Felis concolor, brown spider, fiddleback, brown recluse, Loxasceles reclusa - how many are represented by this list of names? If you decided only two animals, you were correct. As with all organisms, different countries or areas have different names for the same organism. Multiply this by the millions of animals and you can see that a system of identification and naming is needed to organize and study organisms.

During your activities you devised groups based on observable differences and similarities. In addition, scientists study the internal structures and chemical makeup of organisms. When you observed the various parts of plants and animals, you were studying anatomy. Comparing the structures of one organism to those structures of another organism is called comparative anatomy. These comparisons are used to classify the organisms into similar groups. Organisms that have similar structures may be related. The more closely related the organisms, the more similar the structures they will have. As you worked, you identified different groups. Each group was further divided into smaller, more closely related groups. This separation of groups continued until all of the organisms within a group had no significant differences.

Each group was defined as having a set of common characteristics and given a name. The seven major groups from largest to smallest are: Kingdom, Phylum, Class, Order, Family, Genus, and Species. In which group are the organisms most closely related?

The science of classification is called taxonomy. In the 1700's a Swedish botanist named Carolus Linnaeus published a book that classified all of the known plants and animals. Much of today's scientific classification is based upon this early work. The system of naming organisms by their classification still is used. As you can see an organized system of classification and naming of organisms has been devised. Using this system scientists from around the world can communicate accurately with one another.

The table below shows how the common dog and man are classified.

Group	Dog	Man
Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Mammalia	Mammalia
Order	Carnivora	Primates
Family	Canidae	Hominidae
Genus	Canis	Homo
Species	familiaris	sapiens

Since Linnaeus first published scientific classification, scientists have devised numerous schemes to divide organisms into groups. Some scientists divide all organisms into five kingdoms; other scientists divide organisms into as few as two kingdoms. One system has three kingdoms: Animalia, Plantae, and Protista. The following is a summary of these kingdoms.

Kingdom Protista

This kingdom includes those organisms with characteristics that do not fit the typical description of plants or animals, such as protozoa (microscopic organisms that have observable characteristics of both plants and animals), algae, bacteria, viruses, fungi, and lichens.

Many of these organisms cannot be observed well with the naked eye unless many of them are growing together. You have seen mold growing on bread. At some time in your life you have had a virus or a bacterial infection. You could not see the organism but your illness told you that your body had definitely been invaded. Not all Protistans are harmful. Some of the fungi assist man to produce wines, cheeses, antibiotics, and to make bread rise. Other Protistans will have specific roles in the environment which you may explore in future investigations.

Kingdom Plantae

The Plant Kingdom consists of two major divisions. The Bryophyta are small plants that do not have true roots, stems, or leaves, such as the liverworts and mosses. The Tracheophyta are vascular plants that have a system of tubes through which water and dissolved nutrients move. The Tracheophytes are either ferns, gymnosperms, or angiosperms. The gymnosperms include the conifers, such as pines, spruce, and cedars. Their leaves are needle-like. They have well-developed stems and root systems. The angiosperms are the flowering plants. Plants in this class include oaks, elms, fruit trees, grasses, corn and wheat.

Kingdom Animalia

The animal kingdom consists of almost a million different species. Most animals can move their own bodies. Many students are surprised to learn that insects are animals. Yes, even humans are classified as animals since they are capable of movement on their own. Most biologists divide this kingdom into nine phyla:

Porifera (the sponges)

Coelenterata (jellyfish, sea anemones, and corals)

Platyhelminthes (flatworms)

Nematoda (roundworms)

Annelida (segmented worms)

Mollusca (soft-bodied animals)

Arthropoda (jointed legs)

Echinodermata (spiny-skinned animals)

Chordata (back-boned animals).

Let's explore two of the above phyla in more detail.

Phylum Arthropoda

Jointed Legs: More than 90 percent of the members of the animal kingdom are arthropods. These animals have an exoskeleton. There are five classes in this phylum:

Class Crustacea - lobsters, crayfish, shrimp, crabs, pillbugs (roly polys)

Class Chilopoda - centipedes (hundred leggers)

Class Diplopoda - millipedes (thousand leggers)

Class Arachnida - spiders, ticks, mites, scorpions (8 legs)

Class Insecta - grasshopper, butterfly, roaches, beetles, bees, flies (6 legs).

Phylum Chordata

Back-boned animals: All members of this phylum have at some stage in their development a supporting rod of material in the upper part of their body. Most of the chordates have a backbone made of vertebrae, hence the name vertebrates. Think of our vertebral column, or backbone, which protects our spinal cord. Man is a vertebrate but not the only one.

Within this phylum there are several classes with which you are probably more familiar.

Class Pisces (Fish)

The fish includes: (1) The jawless fish such as the lamprey, (2) the cartilaginous fish which includes sharks and stingrays, and (3) the bony fish which are trout, salmon, bass, and perch.

Class Amphibia (Amphibians)

These animals normally live their early life in the water and spend their adult life on land. Included are the frogs, toads, salamanders, and newts.

Class Reptilia (Reptiles)

This class includes the snakes, turtles, lizards, alligators and crocodiles. They have a waterproof skin and eggs covered with a leathery, waterproof shell. The eggs hatch into land-living creatures.

Class Aves (Birds)

Like the reptiles the young birds hatch from shell-covered eggs. Birds are highly specialized animals. Special adaptations that enable them to fly are hollow bones, feathers, and a fused (rigid) backbone that provides an anchor for the wings. The feet and beaks of this group of animals illustrate the adaptability of birds. Their beaks function as spears, tweezers, nutcrackers, shovels, and strainers. All of these adaptations aid the birds in obtaining food. Depending upon their habitat the feet are adapted for running, climbing, grasping, swimming and perching.

Class Mammalia (Mammals)

These animals have hair on their bodies. They give live birth to their young and have mammary glands to provide milk for the young. This class includes the rodents, bats, whales, hoofed animals, and man.

Each organism has a scientific name that is accepted by all scientists. This name has two parts. The first part is the name of the genus to which the organism belongs. The second part of an organism's scientific name is taken from the name of its species. This system of giving organisms two names is called binomial nomenclature.

Greek and Latin words are used to determine the names. These are used because, unlike our modern languages, the meanings of the words do not change. The names are descriptive. These names usually reflect some observable characteristic of the organism's appearance or behavior. Infrequently, organisms are named according to the person who first observed that they were different from another group. The common house cat's scientific name is Felis domestica. Felis means cat or catlike and domestica means domesticated. Felis leo refers to the lion and Felis tigre is the name for a tiger.

Without some type of organization we would probably encounter as many different names as there are people. That would make it very difficult for scientists to communicate with one another.

INVESTIGATION #2: CLASSIFICATION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Classifying Organisms

Below you will find descriptions of the observable characteristics of various organisms. In Table 2-4, classify these organisms according to their correct kingdom, phylum, and class.

1. The King Crab is a marine organism that has jointed legs and a hard outer shell.
2. A minnow is a freshwater organism which has fins, scales and a backbone.
3. A horny toad is a land organism which has a waterproof leathery skin with spines and a backbone.
4. A tick is an eight-legged land organism which has an exoskeleton.
5. An opossum is a land organism which has hair on its body. Their young are born live and each one is small enough to fit on a dime. They crawl into their mothers pouch and nurse until they are several months old.
6. A Monarch butterfly is a land organism and has an exoskeleton. In the adult form, it has wings and six legs.
7. A golden eagle has feathers, a backbone, and lays shell-covered eggs.
8. Daphnia, water fleas, are freshwater organisms that have exoskeletons and jointed legs.
9. A black rat snake has a backbone, a waterproof skin, and lays eggs with a leathery, waterproof shell.
10. Homo sapiens have hair, backbones, give live birth and nurse their young.

Table 2-4

Organism	Kingdom	Phylum	Class
1. King Crab			
2. Minnow			
3. Horny toad			
4. Tick			
5. Opossum			
6. Monarch butterfly			
7. Golden eagle			
8. <u>Daphnia</u>			
9. Black rat snake			
10. <u>Homo sapiens</u>			

11. What are the main differences between the plant and animal kingdoms?

12. List three observable characteristics of mammals that distinguishes them from all other animals.

INVESTIGATION #3: POPULATIONS

Name _____
Section _____ Date _____

INTRODUCTION

Recall the variety of organisms that you have observed in biology. What are the habitat requirements for each of these organism?

EXPLORATION

Organisms at a Study Site

1. Mark the boundaries of the two habitats as directed by your teacher.
2. Take five samples of each of the habitats. Record your estimates in Table 3-1.

Table 3-1

Sample		1	2	3	4	5	6	7	8	9	10	Avg	Number in Habitat
Number of Organisms	Habitat A												
	Habitat B												

3. Observe both habitats carefully. List all the differences in the two habitats.

Table 3-2

	Habitat A	Habitat B
Environmental Variables		
Organisms		

INVESTIGATION #3: POPULATIONS

Name _____
Section _____ Date _____

THE IDEA

1. Record the group estimates of the different organisms in each habitat in Table 3-3.

Table 3-3

Estimated Number of Organisms

Group	Habitat A	Habitat B

2. What is a group of one kind of organism living in the same habitat called?
3. List the differences between the two study sites in Table 3-4.

Table 3-4

	Habitat A	Habitat B
Environmental Variables		
Organisms		

4. Why do you think the size of the population in Habitat A was different from Habitat B?

5. What idea do your data allow you to state?

INVESTIGATIONS #3: POPULATIONS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

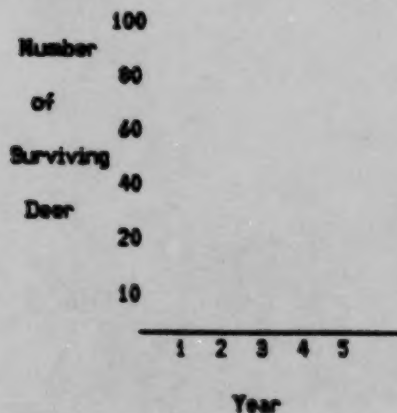
Habitat Limits

1. Complete the chart below from class data.

TABLE 3-5

Year		Number of Deer at Start	Number of Survivors	Births
1	Start Normal Number			
2	Surviving Deer Reproduce			
3	Surviving Deer Reproduce			
4	Surviving Deer Reproduce; is damaged			
5	Same as Year 4			

2. Graph the class data.



3. What do we call the number of individuals an area can support?
4. What is the limiting factor for the deer's habitat?
5. List other factors that may affect the carrying capacity of a habitat.
6. If a person regularly, and for a long time, provided a lot of corn for a population of deer in a small area, what would happen to the carrying capacity of that area for deer? What would be the effect on the deer if the person moved away?

INVESTIGATION #3: POPULATIONS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Increasing Numbers

1. Estimate the number of offspring produced by one parent. Record this number on Table 3-6.

Table 3-6

Parent	Offspring
_____	_____
_____	_____
_____	_____

2. Calculate the following informations: Number of possible offspring if all the young of the parent survive _____. Amount of space required for all of the offspring _____.
3. Complete the chart below.

Table 3-7

Organism	Number of Young Produced During Life Span	Possible Number of Young Produced by Offspring
Corn	6,000	_____
Dog	30	_____
Man	4	_____

4. The number of offspring a parent can produce is called _____.
5. List your evidence that shows what would happen if all organisms reached their full biotic potential.
6. Give two reasons why organism do not attain full biotic potential.

INVESTIGATION #3: POPULATIONS

EXPANSION OF THE IDEA

READING: Limiting Factors Controlling Animal Populations

Everyone has read the biological forecasts. 'If two rabbits (or squirrels or sparrows) started reproducing today, by the year 2000 the world would be covered by a 12-mile thick layer of rabbits (or squirrels or sparrows).' Of course, these examples are pure mathematical equations based on known reproductive rates for a species. But each example raises the question, Why don't animals ever attain this maximum biotic potential?

Each animal species has its own reproductive rate, a distinct amount of time required by mature breeding stock to produce another generation of breeding stock or mature removable crop. And, as with just about every other biological principle, this rate depends heavily on habitat. Elements of habitat serve key roles in determining how many offspring are produced, how many are consumed by natural enemies and how many, if any, are available for hunter harvest. Elements of habitat limit just how many animals can live under available environmental conditions.

Under the broad and loose term "limiting factors" are two ways by which maximum productivity is restricted. The environment resists the unlimited increase of a species population by means of decimating factors, those which directly kill individuals of the population, and by means of welfare factors, influences which reduce or inhibit successful breeding and weaken natural defenses against decimating factors. Most often these factors overlap and interact to control productivity and limit distribution of animals.

Disease and parasites serve as effective decimating factors, not only on local populations, but also on a larger scale. A good example is the brainworm, which is rarely lethal in the animal it infests most frequently, white-tailed deer. However, the parasite is almost always fatal to the deer's close relative, the elk. The brainworm seems to survive only in the hardwood forests of the eastern U.S. The abundance of this parasite in the eastern U.S. is one of the main reasons there are no free-roaming elk herds in that portion of the country.

Identifying a single limiting factor is difficult, especially when discussing how large an area an animal species covers, because in every case a complex set of environmental variables is involved. Any animal requires a number of elements in its habitat (food, water, cover, temperature) and can tolerate some variation in the quantity of any one of them. But any condition which nears or surpasses the limits of tolerance for that animal becomes a limiting factor for the species. Such is the case for rainbow trout. Rainbow trout have an upper tolerance for water temperature of 83 degrees Fahrenheit. But the true limiting factor is oxygen.

Just as land animals remove life-giving oxygen from air, fish remove it from water with their gills. Trout require at least four to five parts per million of dissolved oxygen in water, or they can't survive. Since cold water holds more dissolved oxygen than warm, the availability of cold water is essential to these fish. Consider a can of Coca-Cola. Which opened can will lose its fizz (dissolved gas) more quickly, a cold can or one at room temperature? If you're not sure try it and find out. Needless to say, many bodies of water in the U. S. contain water too warm, at least part of the year, to maintain the high oxygen requirements of trout. Mountainous regions can provide cold water during most of the year. The bottleneck of summer's warm water temperatures offers two clues about limiting factors. They can be seasonal, and they often relate to weather and climate.

In northern climates, winter more than summer controls the extent to which animal populations expand each year. During winter, extreme cold, reduced amounts of cover and corresponding decreases in food supplies all contribute to pare down numbers from spring and summer population peaks. One season of the year may be less favorable to a species than other times of the year.

With birds, weather during breeding and nesting season is the most critical factor. Late snows, ice storms or even prolonged cold rainy spells are conditions which stress or even kill nesting quail and pheasant. Recently hatched chicks are even more susceptible to these storms. Young birds can starve over a two or three day period. Therefore, quality nesting cover and its corresponding food supply are limiting factors for both quail and pheasant.

With weather and climate often limiting species distribution, summer heat and moisture can play a major role in the size of population. For example, pheasants have been stocked in many states, but the transplants have never successfully established breeding populations for any length of time. Pheasants are numerous in more northern states with cooler, wetter summer weather, so prolonged heat and drought may help limit the southern extent of pheasant range.

Instead of direct mortality restricting range, pheasants are also controlled to some extent by a welfare factor. One restrictive factor may be the mineral content of grit which these gallinaceous birds ingest. Without the right minerals, pheasants lay faulty eggs with thin shells or don't breed at all. Transplanted birds survive for a few years, but without adequate reproduction the population is doomed. So pheasants are limited to areas where the necessary grit is readily found.

Another factor, a decimating one this time, also helps determine the fine line between having pheasants and not. Chiggers are mere annoyances to humans and large mammals, but these members of the mite family can kill recently hatched chicks. The dryness and cold weather of the northern states controls chiggers, and where chiggers are scarce, pheasants are found.

Biologists have yet to determine the exact set of limitations which restrict pheasants to the areas they currently inhabit. Most likely it is a complex interaction among welfare and decimating factors and climate. But whatever the reason, it works.

Another limiting factor in some eastern regions takes the form of a rifle bullet. In some areas, poaching is considered a limiting factor on deer herd productivity. All other requirements may be present for sustaining a larger deer population, but if a decimating factor keeps mature adults from breeding, then the population won't approach its maximum breeding potential as determined by habitat. Legal deer hunting harvests a rather low percentage of the excess numbers normally produced. A good brood stock always remains after legal harvest.

Poaching, on the other hand, overkills the more accessible animals (usually does) in too great a number, thus reducing the replacement capabilities of a herd. Legal hunting usually harvests less than 10 percent of deer populations, while year-around poaching may claim 80 or even 90 percent of a herd. Thus, long-term poaching is a severe decimating factor against a local herd's productivity.

Of course, not just game birds and game animals suffer the restrictions of limiting factors. Every living organism, whether it is a plant or an animal, has its productivity controlled. Local populations are controlled, regional distribution is controlled, and even the continental range of animal populations are limited.

Chances are the details of limiting factors will never be completely understood for every species. Limiting factors take all forms and they resist maximum animal productivity in many ways. The wildlife manager attempts to improve habitat by seeking out limiting factors which he can economically and feasibly remedy. Some factors can be altered, others can't. There are limits even to the things humans can accomplish.

Adapted from "Limiting Factors...and the control they exert on animal populations" by Bruce Stomp, Outdoor Oklahoma, January/February, 1982.

INVESTIGATION #3: POPULATIONS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Limiting Factors Controlling Animal Populations

1. What are the major limiting factors controlling animal populations in the following regions of the U. S.? Provide one example for each region.

Table 3-8

Region	Limiting Factor(s)	Example
a. north		
b. south		
c. east		
d. west		

2. What limiting factors do man's activities impose on all animal populations?
3. Choose a natural population in your state. Give one example of how a limiting factor has restricted the size of this population.
4. Defend or refute the following statements: hunting is bad for a deer population.

INVESTIGATION #4: PRODUCERS

Name _____
Section _____ Date _____

INTRODUCTION

A habitat includes water, food, and cover for an animal population. Plants provide cover in many ways for animal populations. What provides the food for the animal population?

EXPLORATION

Light and Dark

1. Label a strip of foil and carefully attach it to a leaf. Draw the leaf showing the part covered by the foil in Table 4-1. Label the color of each area of the leaf. After 48 hours complete the following procedures using your team's leaf.
2. Place the leaf in boiling water for five seconds. Using a spoon, transfer the leaf to the alcohol bath. (Alcohol is flammable!)
3. Boil the leaf until it is white. Remove the leaf from the alcohol. Place it in a small amount of water in a petri dish (or on a slide). Gently spread the leaf out flat. Leaves may be brittle, so handle them carefully. Draw the leaf in Table 4-1.
4. While holding the leaf flat, pour off the water. Add just enough Lugol's iodine solution to cover the surface of the leaf. (If using a slide, cover the leaf with a second slide, tape each end and save.) After a few minutes draw the leaf in Table 4-1.

Table 4-1

	Before Boiling	After Boiling	After Lugol's
Leaf			
Drawing			
and			
Color			
of			
Leaf			

5. In which portion of the leaf is starch present?

INVESTIGATION #4: PRODUCERS

Name _____

Section _____ Date _____

EXPLORATION

Variegated Leaves

1. Remove one variegated leaf from the plant. Draw the leaf on Table 4-2 and label the color of each area of the leaf. Complete the following procedures using the leaf you removed.
2. Place the leaf in boiling water for five seconds. Using a spoon, transfer the leaf to the alcohol bath. (Alcohol is flammable!)
3. Boil the leaf until it is white. Remove the leaf from the alcohol. Place it in a small amount of water in a petri dish (or on a slide). Gently spread the leaf out flat. Leaves may be brittle, so handle them carefully. Draw the leaf in Table 4-2.
4. While holding the leaf flat, pour off the water. Add just enough Lugol's iodine solution to cover the surface of the leaf. (If using a slide, cover the leaf with a second slide, tape each end and save.) After a few minutes draw the leaf in Table 4-2.

Table 4-2

	Before Boiling	After Boiling	After Lugol's
Leaf			
Drawing			
and			
Color			
of			
Leaf			

5. In which portion of the leaf is starch present?

INVESTIGATION #4: PRODUCERS

Name _____
Section _____ Date _____

THE IDEA

1. Summarize the class data on Table 4-3.

Table 4-3

Plants Placed in the Light:

	Group	Covered Area	Uncovered Area	Green Area	Non-Green Area
Starch	1				
was	2				
Present	3				
in the	4				
leaf	5				
(Check,	6				
if	7				
yes)					

2. What substance is produced by plants in the light?
3. What color (or pigment) must be present for starch to be made?
4. List the things that are needed by plants to produce starch.
5. What idea do the data allow you to state about green plants?

INVESTIGATION #4: PRODUCERS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Starchy Foods

1. Test each of the following substances with Lugol's iodine solution. Record your results by listing the color after testing.

Table 4-6

Substance Tested	Results	
	Positive	Negative
Water		
Starch Solution		

2. Which substances contain starch?
3. Which substances do not contain starch?
4. What group of organisms store starch?

INVESTIGATION #4: PRODUCERS

EXPANSION OF THE IDEA

Reading: Death of a Producer

It was a lazy Saturday morning as Mr. Hudson began fishing in his new pond. Actually, it had been over four years since the dam was built. Three summers had passed since stocking the pond with fish. The water had cleared. It reflected the blue of the sky.

"A strike!" Mr. Hudson yelled, as if to let his cows in on the thrill of landing a big one. As he fought the fish close to shore, it became snarled in the Elodea, water plants, growing a few feet from shore. As quickly as it had struck, the fish was gone! Mr. Hudson labored to reel in several long strands of the fuzzy green plant.

"Darn that stuff," Mr. Hudson thought. "I didn't realize so much had grown. Well, I'll fix that." He drove back to the barn and got a chemical he knew would kill most of the Elodea. He returned to the pond and applied the amount of the herbicide recommended on the label.

A few weeks later Mr. Hudson decided he would try his luck again. As he topped the dam he couldn't believe what he saw and smelled! All along the shore where the Elodea had been was a dark slimy foul smelling blob. Bloated and floating belly side up were hundreds of fish. Among the large ones, Mr. Hudson knew he recognized "the one that got away." He felt both sad and angry. His thoughts of disbelief turned into confusion and anxiety. "How had this happened?" he wondered. The herbicide chemical he had used was not toxic (poison) to animal life--only plants.

Not sure of just how to handle this problem, Mr. Hudson decided to call the Game and Wildlife Department. As he explained what had happened to the biologists at the department, he was relieved to hear that he had correctly used the chemical. It was not directly responsible for the death of the fish. The biologist suggested that he come to the pond to do some tests on the water. The biologist had made a hypothesis based on Mr. Hudson's story of what happened and wanted to test it.

The next day the biologist brought his equipment out to the pond. He took several samples of the water from different places around the pond and some at different depths. The results of the testing verified his hypothesis. The amount of oxygen in the water had decreased below the limit that could be tolerated by most of the fish.

The biologist suggested that Mr. Hudson remove the dead Elodea and the dead fish by dredging the pond. He explained to Mr. Hudson that in a few weeks when the bad smell was gone, the pond would again contain the normal levels of oxygen. Of course it would take three or four years after restocking with fish before Mr. Hudson could try again for "that big one."

Mr. Hudson shook his head in disbelief? What did dead plants have to do with the oxygen content in the water?

The biologist realized his confusion and set up an experiment for Mr. Hudson to observe.



First, he prepared two identical set-ups in the following manner: several sprigs of healthy Elodea were placed at the bottom of a funnel. The inverted funnel was positioned in a large beaker of water. A test tube full of water was inverted over the narrow end of the funnel. One set up was left in the light and another in the dark. After several days the biologist and Mr. Hudson observed the two set ups. A gas had collected along the Elodea sprigs and within the test tube left in the light. What was the identity of the gas? The biologist removed the test tube and placed a glowing splint into its mouth. It burst into flame! The gas was oxygen.

Now Mr. Hudson understood the relationship between the dead plants and the dead fish. Green plants use light energy to produce oxygen. Photosynthesis is responsible, once again!

This process enables green plants to use light. In addition to food, the producers also give off oxygen. In fact, all the world's green plants supply the earth with oxygen. Eighty percent of the world's supply of oxygen is produced by the large numbers of algae (phytoplankton) floating in the top layers of the oceans. Consider this, pollution of the oceans may harm the algae and lower the amount of oxygen produced by photosynthesis. (That would create a bigger problem than Mr. Hudson's!)

Without photosynthesis, life as we know it would not exist. Without our source of food and oxygen production where would we be?

INVESTIGATION #4: PRODUCERS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

READING QUESTIONS: Death of a Producer

1. Which environmental variable killed the Elodea?
2. Which environmental variable killed the fish?
3. At what point did these environmental variables become "limiting factors"?
4. A friend cleans out your aquarium and removes all of the soil and plants, leaving only the fish and water. Predict what will happen.
5. A popular bumper sticker asks, "Have you thanked a green plant today?" Give two reasons for thanking a green plant.
6. Trace back the materials comprising the sticker and see whether the sticker itself represents an application of the slogan.

INVESTIGATION #5: FOOD CHAINS

Name _____
Section _____ Date _____

INTRODUCTION

Green plants are able to make their own food, but where do animals get their food?

EXPLORATION

Food Sources

1. Observe the animals as directed by your teacher. Record your observations on Table 5-1.

Table 5-1

Organism	Feeding Observations

2. Which organisms eat only producers?

3. Which organisms eat other animals?

INVESTIGATION #3: FOOD CHAINS

Name _____
Section _____ Date _____

THE IDEA

1. Record the data from the Exploration on Table 5-2.

Table 5-2

Organism	Food Role
Which animal ate the animal that ate the producer?	
Which animal ate the producer?	
Which organism was the producer?	

2. What idea do the data allow you to state?

INVESTIGATION #5: FOOD CHAINS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Rotten Food

1. Carefully examine the specimen provided. Record any changes that may have occurred on the specimen and carefully describe any foreign growth.

Table 5-3

Specimen	Observations

2. Describe the changes that occur when an organism dies. Use observations from your class terraria, aquaria, or other previous investigation.
3. What caused the changes you observed in the rotten foods?
4. What happens to an organism when it dies?

INVESTIGATION #5: FOOD CHAIN

EXPANSION OF THE IDEA

Readings: Producers and Consumers

Studying a prairie dog town can teach us a great deal about the interrelationships that exist between different animal species, between plants and animals, and between all living things and the sun.

Through a process called "photosynthesis," chlorophyll absorbs light energy from the sun and uses it to make food. The food produced is a sugar, which is further stored as starch in the plant. When a prairie dog eats grass, the stored energy and material in the starch is passed along to the prairie dog.

A prairie supports much more than just grass and prairie dogs. A hungry coyote in search of food may come upon a prairie dog town. If the opportunity presents itself, the coyote may catch and eat a prairie dog. In that way, the energy in the prairie dog's body will be used by the coyote in meeting its own energy needs.

The sequence of getting food energy and providing food energy extends from sunlight and plants throughout a long series of plant and meat-eating animals called a food chain. The first level of the food chain is the grass that turns the sun's energy into food. Because the grass creates its own food, it is called a producer. The prairie dog is at the next level, that of the primary consumer, or herbivore, because it is the first animal to utilize the energy produced by green plants. Because it eats the plant-eating prairie dog, the coyote is called a secondary consumer, or carnivore. Anything that ate a coyote would be called a tertiary consumer, and so on through the food chain.

There can't be more prairie dogs than grass, and the coyotes cannot outnumber the prairie dogs. Hundreds of grass plants must be eaten by each prairie dog every week, and each coyote must consume three or more prairie dogs. This means that each coyote consumes the equivalent of thousands of grass plants each week. At first glance, this seems like much too great an amount of food for just one coyote. But, we must keep in mind that most of the energy and materials making up the grass plants was used by the prairie dog as it grew, ran or dug its burrow. This is why biologists see the food chain as a type of pyramid, with the numerous producers as the broad base, and fewer consumers in the higher levels nearer the pointed top.

The prairie dog is eaten not only by coyotes but also by hawks, foxes, owls, snakes, bobcats and other carnivores. Similarly, in lakes, minnows are taken by bass, bluegills, herons, egrets and other consumers. In any example, the food chains of different consumers overlap wherever they share a common food source. Such an interlocking of food chains has lead biologists to speak of food webs when discussing food transfers, rather than interpreting wildlife interactions in terms of the simple food chain alone.

An animal may occupy several positions within the web at one time. A bass, for example, may eat a minnow, making the bass a secondary consumer. But the same day the bass eats the minnow, it may come across a bluegill that is also eating minnows. If the bass is still hungry, it may catch and eat the bluegill, thereby becoming a tertiary consumer.

The same holds true of a raccoon eating both berries and crayfish. Eating the fruit puts the raccoon at the primary consumer energy level, but eating the crayfish puts it at the secondary consumer level. Raccoons also will eat frogs, which are secondary consumers. On any given night of feeding, therefore, the raccoon may be a primary, secondary and tertiary consumer! A critter such as the raccoon which may feed on both plants and animals fulfills the role of both a herbivore and a carnivore. Another example is the opossum which has a wide range of food sources from which to choose in the southern U. S. It may scavenge from garbage cans, devour ripe fruit, dine on insects or search for bird eggs. Such animals are said to have a generalized diet and are called omnivores.

By contrast, the black-footed ferret, a small prairie weasel thought to be extinct in the American southwest, feeds almost entirely on prairie dogs and, in fact, is most likely to be found living in prairie dog burrows. The black-footed ferret, with its limited number of preferred foods, is said to be "specialized." Although specialization gives the ferret an advantage over the coyote in catching prairie dogs, it can create a deadly trap for the ferret. If prairie dogs should decline over a coyote's home range the coyote will simply switch to eating something else such as rabbits or quail eggs. But if prairie dogs disappear so do the ferrets!

In fact, that is exactly what has happened. Intensive efforts by landowners to exterminate the prairie dog, which competes with livestock for grazing lands, has eliminated the prairie dog over much of its former range. Therefore, the ferret, with its energy source gone, has all but disappeared.

Many other specialists, unable to cope with rapid changes in their environments, are included with the black-footed ferret on the endangered species list.

A predator is an animal which gets its energy from eating other animals. Under natural conditions, predation is beneficial not only to the predator, but to the prey species as well.

Coyotes, because they are larger and slower than their prey, are able to catch only the less fit members of the prey species. By killing off the weaker individuals, the coyote insures that only the stronger survive, thus helping to keep the prey species a healthy one.

Culling members of the prey species also keeps the prey from over-populating an area and starving to death when the area's food sources become depleted. For example, in small farm ponds stocked with largemouth bass and bluegill, the bass prey upon the bluegill. If fishermen catch too many bass, however, the bluegill population explodes. Soon, the bluegill run out of their natural food and their population goes into decline. Predator prey interaction within a food web keeps animal populations in balance.

If predators are useful, then why are they so disliked? Predators, viewed by many as blood-thirsty killers, have been much maligned by man. In predator-prey interactions, humans have always given their sympathies to the apparent underdog-the cute, fluffy rabbit or the brown-eyed deer.

Do predators threaten the existence of prey species? As the population of prey species reaches its maximum number and begins to diminish, predators dependent on the prey, finding less and less food, also decline in numbers. In time, the number of predators will be so reduced that prey reproduction will climb once again. Predator populations respond to the abundance of prey.

The relationship between white bass and threadfin shad illustrates this interdependency. In the southern U. S., the white bass were for many seasons dependent on the shad for food. Threadfin shad, however, cannot survive severe cold, and when two consecutive, extremely cold winters blew into this area, the shad population fell. White bass, losing their primary food source, also suffered. Fishermen noticed they were catching fewer white bass, and biologists noticed the bass caught were smaller and less healthy than those of earlier years.

Should this process continue, one might expect the white bass population to drop to such a low level they will exert minimal predatory pressure on the shad. If the shad then make a comeback, their numbers increasing to a peak, white bass should increase in number, too.

This shows how prey species are very important to predators. Without prey, the predators will die. Consequently, no predatory species will, under natural conditions, wipe out its prey. Long before the predators can kill off all of the prey animal, the predators will themselves go into decline.

This is so for two reasons. One is predators usually have very low reproductive rates, while prey species usually have high reproductive rates. In this way nature insures more animals are available at lower than at higher consumer levels. Furthermore, some studies have shown that as food becomes harder to find, at least some predators slow or stop reproducing, presumably because of a lack of the proper nutrients for successful propagation.

The fear that predators will wipe out their prey is founded only on a human emotional reaction sympathetic to the animal killed by a predator. It is important to understand, however, that although individual members of the prey species may die, the prey population is left intact and survives. The fear that predators will kill off a prey population has no foundation in truth.

Yet, as wildlife biologists know, the predators, not their prey, are in trouble. When the population number is determined to be too low then a species may be listed by federal and state agencies as an endangered species.

This reading taken from Critters and Concepts prepared by the Oklahoma Department of Wildlife Conservation.

INVESTIGATION #5: FOOD CHAIN

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Producers and Consumers

1. What type of consumer are raccoons?
_____ Why are they placed into this category?
2. Explain whether or not a single predator species (such as the raccoon) can be placed in more than one level of the food pyramid.
3. In what way is the ferret more specialized than the coyote?
4. Why have many animals and plants become endangered?
5. List two ways a predator (coyote) BENEFITS its prey (rabbit).

INVESTIGATION #4: ECOSYSTEM

Name _____
Section _____ Date _____

INTRODUCTION

You have observed many plant and animal populations. How are those populations affected by other populations? How are those populations affected by environmental variables?

EXPLORATION

Population Changes

1. Observe the organisms. Name or sketch each different type. Count the number in each population. Measure the environmental variables. Record your data on Table 6-1.

Table 6-1

Date	Organisms and Interactions Observed	Description of Environmental Variables

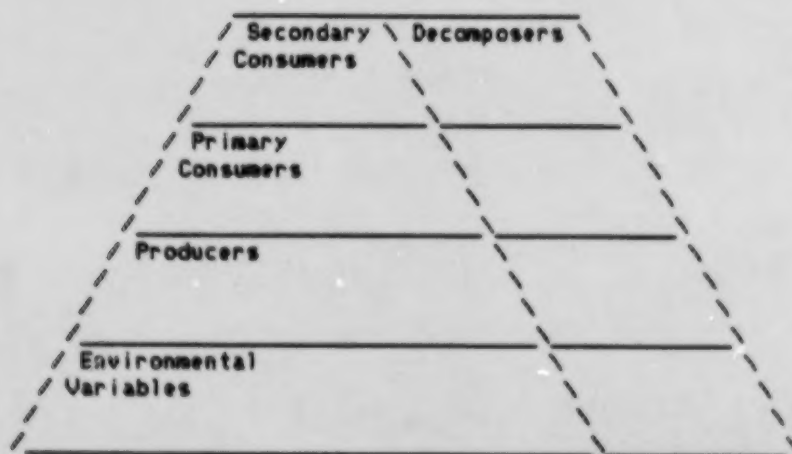
INVESTIGATION #6: ECOSYSTEM

Name _____
Section _____ Date _____

THE IDEA

1. Complete Table 6-2 with the class data.

Table 6-2



2. Summarize the changes in the populations that took place during the time you made observations.
3. Summarize the interactions between populations that you observed.
4. What do these data suggest about populations that live in the same area?
5. Summarize the changes in the environmental variable that took place during the time you made observations.
6. What idea do the data allow you to state?

INVESTIGATION #6: ECOSYSTEM

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Showdown

1. Make the observations as directed by your teacher.
Record the data on Table 6-3.

Table 6-3

Date	Organism	Observations of Interactions

2. What idea do the data allow you to state about the interaction between organisms of the same species?

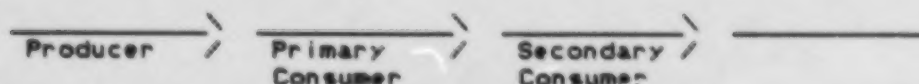
INVESTIGATION #6: ECOSYSTEM

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Problem: Lifestyles

The food chain from the food web that your group will investigate is the following:



Answer the following questions about the organism you were assigned to investigate:

Common Name? _____ Scientific Name? _____

1. What food does it eat?
2. How and where does it find and capture its food?
3. What extremes of heat and cold, dry and wet, sun and shade, and other physical factors can it withstand? In other words, what are its optimum ranges, if any, for the environmental variables?
4. What time of year and/or day is it most active?
5. What are its predators and parasites?
6. Where, how and when does it reproduce?

INVESTIGATION #6: ECOSYSTEM

EXPANSION OF THE IDEA

Reading: Ecosystems in North America

Your aquarium was an example of a microecosystem. The interactions between the populations you included in the aquarium and the environmental variables you maintained formed an ecosystem.

If you were successful in your microecosystem, the populations coupled with the environmental variables contributed to maintaining a healthy balance even though your system is small. If the water became too murky and/or the light was lost, the water plants may have been killed. If the plants died, the snails, daphnia, or other water invertebrates would be without food and oxygen. Without the primary consumers and the oxygen they produce, the small fish would die. If many things died then the number of decomposers would increase. Your nose would tell you what had occurred. Just because one variable had become a limiting factor: catastrophe and a dirty, smelly clean-up job!

Ecosystems can be as small as an aquarium or as large as a biome. A biome is a broad geographic region having the same climate. They are generally named according to the most common or dominant group of plants inhabiting the area.

Some biomes are terrestrial. For example, much of the northeastern United States has a biome called the temperate deciduous forest. The desert in the American southwestern states is a biome as is the belt of grassland in the midwestern states. Other biomes are aquatic such as the ocean. Biomes are major divisions of the living portion of the earth—the biosphere.

Climate determines what populations of plants and animals are located in the biome. The variables influencing climate include temperature, rainfall, and sunlight. Nearness to mountains or to large bodies of water are also factors.

Let's consider one environmental variable, temperature. Can you determine how temperature becomes, a limiting factor in these four biomes?

The Arctic Tundra

Tundra areas in North America may be found near the Arctic Circle. In the U. S., northern Alaska is considered to be arctic tundra. Also, alpine tundra is found at high elevations in the Rocky Mountain region depending upon the latitude. Winter temperatures in this region are very cold. The average January temperature is about -15° F. During this time all of the available water in the soil and shallow bodies of water are frozen solid. In the short summer the earth's surface thaws but remains permanently frozen below the surface to depths of 2,000 feet. This layer, known as the permafrost, prevents the soil from draining properly. Swampy areas form at the surface since the permafrost prevents good drainage. Houses are often built on stilts. Why? If built directly onto the surface the heat radiated from a house will melt the permafrost. The house will sink into the ground.

The environmental variables of the tundra fluctuate greatly from season to season. Day length can range from 24 hours of daylight in the summer to 24 hours of darkness in the winter. The lack of light in the winter explains the low temperatures. The growing season is about two months.

Thawing of the ice and snow provides most of the available water since rainfall is low. Most plant populations are low growing varieties such as birches, willows, mosses, and hardy grasses. Tundra plants spread along the ground instead of growing upwards. Buds have special waxy coats to prevent freezing. Lichens cover the rocks and soil.

The animal populations of the tundra can withstand the bitter cold. Many of the animals have body shapes that reduce heat loss. For example, the polar bear is round and large. The musk ox and caribou have warm coats. The musk ox has long hair with thick wool underneath. The caribou has hollow hair which provides insulation and buoyancy. The small rodents of the Arctic live under the snow. They eat plants that grow during the summer. Many of the animals in the arctic tundra change color with the seasons. They are dark in the summer and light in the winter. Other animals that cannot tolerate the extreme winter cold migrate to warmer habitats during the winter freeze.

The Coniferous Forest

As you move south of the arctic tundra, the environmental variables are not as harsh. This area just south of the tundra in southern Canada and the northern U.S. is called the coniferous forest or taiga. The summer days are short, but more of the sun's warmth is received. It is still very cold during the winter, the low temperature is about -20° F. The summer high is about 70° F and the growing season is much longer than in the tundra. Summer rains provide most of the moisture. The snowfall and rain provide about 30 inches per year.

The dominant plants of this area are the coniferous evergreens. These include the Douglas fir, Sitka spruce, and the Balsam fir. The evergreens shade the forest floor. In the shade of the evergreens few plants grow except ferns, mosses, and herbs.

The variety of animals in the coniferous forest is greater than in the tundra. As in the tundra, animals here must be adapted to survive long cold winters. The animals that remain active during the winter have heavy insulation. The moose, wolves, foxes, and weasels grow thick winter fur. The smaller animals such as the rodents live beneath the snow with spaces provided by plant growth. Here the snow provides insulation, preventing the temperature from dropping too far below freezing. The types of insect populations are limited. But each of the insect populations is great in number.

The Temperate Deciduous Forest

As you move further south, the area supports the deciduous forests. The climate of the deciduous forest is not as severe as in the coniferous forest. The temperature is more moderate from lows of 10° F to 60° F in January to highs of 70° F to 80° F in July. The rainfall is abundant, 40-50 inches per year, and evenly distributed throughout the year. Plant growth normally occurs in several layers. There is a canopy of tall trees that form an umbrella-like covering. Beneath this layer much of the light has been filtered through the leaves. Here an understory of smaller, shade tolerant hardwoods grow. The next level is occupied by shrubs that do not require much light. At ground level, ferns, mosses and other small plants compete for the remaining sunlight.

The dominant forest populations in the northern part of this forest are beech and maple trees. In the southern part the dominant trees are the oak and hickory. Within this forest you will find elm, sycamore, poplar, and willows.

The environmental variables which allow the forest to develop, in a manner of speaking, determine the animal populations present. The forest provides a variety of habitats for the animals. This variety of habitat in the deciduous forest results in a greater variety of animal life than in the coniferous forest. Deer, elk, bears, raccoons, opossums, crows, rabbits, squirrels, beavers, and woodpeckers are just a few of the animals found in the deciduous forest.

The Tropical Rain Forest, or Jungle

Accompanying the constant warmth of the tropical rain forest is an abundant rainfall, 80-120 inches per year. Tropical rain forests are found in Central America. If you were standing on the forest floor it would appear dark. The vegetation is very dense. Vines grow around the trees. Actually, plants grow on other plants for support. They obtain their moisture directly from the humid air. Trees grow to great heights. Since it is continuously summer, they do not shed their leaves. Many varieties of plants and animals are present.

In North America two other biomes are found: the grassland or prairie and the desert. The limiting factor in these regions is water rather than temperature.

The Grassland

The grasslands of North America occupy the same latitudes as the deciduous forest. The major difference lies in the amount of rainfall. Most of the grasslands receive from 10 to 30 inches of rainfall per year. The rainfall is often irregular, resulting in drought.

Populations living in this biome must be able to cope with the irregular water supply. Grasses can survive on little water. The soils are among the richest in the world. This explains why most of this land now is used to produce grain for our hungry world. Tree growth is restricted to the streams and rivers that pass through the prairies. The dominant tree is the cottonwood. The animal populations in this area include the coyotes, ferrets, prairie dogs, hawks, snakes and badgers. Most of these have keen vision and speed.

The Desert

As in the tundra, the environmental variables greatly affect the desert populations. Populations of this region must be able to withstand extreme heat, cold, and lack of water. The average temperature in the southwest desert of the United States is 68° F. This does not sound hot, but this includes the cold winter temperatures. Summer temperatures may reach 134° F in the shade. Rainfall in the desert averages less than 10 inches per year. All of the rain may fall in only one or two days of the year. The rain that does fall cannot soak into much of the sun-baked soil, causing floods. Floods erode the fragile soil of the desert. Much of the water absorbed by the soil is evaporated into the air. It cannot be used by the plants and animals.

Most plant populations in the desert have shallow root systems that spread out in all directions. This allows the plant to quickly absorb the available water. Some plants like the mesquite have tap roots that reach more than 100 feet beneath the desert surface. Others have roots which produce chemicals that kill plants that grow too close to them. Many of the plants in the desert are succulents. They can store large amounts of water.

The animal populations of the desert must cope with the water shortage. Most desert animals are small. They avoid water loss by coming out only at night or at dusk or dawn. Some of these small animals need not drink water at all. They can use water produced by the breakdown of food. The dry, scaly skin of the reptiles and the hard coverings of insects help to reduce their loss of water. Periods of dormancy enable some animals to survive in the desert. The ground squirrel becomes dormant during the hottest part of the summer. Birds are among the most active populations during the heat of the day. Flying enables them to escape the scorching heat of the desert floor.

Every population is affected by the environmental variables of its habitat. Each variable in some way determines the size, health, and diversity of populations found within an area. Each change in environmental variables affects the populations that can live in an area. The plant and animal populations living in a region with specific environmental variables make up what we call a biome. You have just read about the populations found in the major biomes of North America. Other biomes exist throughout the world.

INVESTIGATION 86: ECOSYSTEM

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Ecosystems in North America

1. Explain how the environmental variables in a tundra and a desert are different.
2. In what biome do you live? _____
Give two examples of how an environmental variable affects: a plant population in your biome; an animal population in your biome.
3. Give two examples of how an animal is adapted to live in extreme cold.
4. Is the earth's climate warming or cooling? Scientists disagree as to what is occurring. One school of thought believes that as more particulate matter from the burning of fossil fuels is introduced into the air, the sunlight will be blocked from reaching the earth. This could cause a worldwide decrease in temperature. Could this be the signal of another Ice Age? However, climatological data kept over the past 100 years have shown a slow but steady increase in worldwide temperatures. If the earth is warming, predict the consequences for the following biomes: the tundra; your biome.

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

INTRODUCTION

Some 1.5 million animals, plants, and protists have been named and classified. Estimates show that there may be five million species in our world. Throughout this great diversity of organisms there is a common denominator. What is it that all living things have in common?

EXPLORATION

Plants

Follow your teacher's instructions to observe several different plant specimens. When preparing cross-sections use the following procedures:

1. Very carefully slice a thin section of the material. Be sure to slice away from you. The section of material must be thin enough to see through.
2. Using the forceps, place the section of the material on the slide, add one drop of water and put the cover slip in place. If the cover slip tilts, the slice is not thin enough.
3. Using the low power objective find the thinnest area of the material section. Look at the edges of the material. Now turn to high power and focus on the material.
4. With the high power objective focused on the thinnest area of the material section, make your observations.
5. Draw a small section of what you see.

Title _____
Magnification _____X

Title _____
Magnification _____X

Title _____
Magnification _____ X

Title _____
Magnification _____ X

6. Describe the ways in which each of the plants were alike.

7. List two differences you observed in the plants under the microscope.

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

EXPLORATION

Animal _____

1. Place a drop of stain in the center of the slide.
Stain used: _____.
2. Gently scrape the inside lining of your cheek with a toothpick. Use the large flat end of the toothpick. Mix the scraped material with the stain.
3. Add the cover slip.
4. Using the low power objective, locate the specimens.
5. Make drawings of at least two specimens under high power.

Cheek Cells

Magnification _____X

6. Describe the specimens observed on this slide.

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

THE IDEA

Plant

Animal

1. What did you observe in both the plant and animal specimens?
2. What idea do the data allow you to state?

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Onion Cells

1. Using the procedure described by your teacher, prepare a wet mount of onion skin.
2. Make sure the onion skin is smooth and add one drop of water.
3. Focus on low power, then switch to high power. Draw several cells at high power.
4. Touch the edge of the water beneath the cover slip. This will remove the water that surrounds the onion skin.
5. Gently remove the cover slip and add one drop of stain directly to the onion sections. Replace the cover slip.
6. Observe the sections under low power and high power. Draw several areas at each power.

Unstained Onion

Stained Onion

7. What differences are there between stained and unstained sections?

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Elodea Cells

1. Place a drop of water on the slide.
2. Using your forceps remove a green leaf from the growing tip of a sprig of Elodea and place it in the water on the slide. Add the cover slip.
3. Using the lower power find the thinnest part of the leaf. Change to high power and focus again carefully. Look towards the tip of the leaf. Focus and center the specimen.
4. Draw your observations on high power.

Elodea _____ X

5. How do the onion sections and the Elodea sections appear different?
6. How do they appear similar? Use drawings and written descriptions to support your answer.

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Class Discussion

Typical Plant Cell

Typical Animal Cell

1. Compare the border of the plant cell to the border of the animal cell?
2. Describe what you saw inside the stained cell.
3. What was found in the Elodea cells that was not found in the onion cells?
4. What is the purpose of these bodies?
5. Compare the structures of plant and animal cells.

INVESTIGATION #7: CELLS

EXPANSION OF THE IDEA

Readings: Units of Life

Earlier you observed many organisms as they exist in the natural world. Now you have taken a closer look at the way in which those organisms are constructed. What makes a living thing different from a non-living thing?

Imagine removing a piece of cork from under the bark of an oak tree. Do you think that it might look similar to the cell that you have observed? Robert Hooke (1635 to 1703) did just that. Following is an excerpt from his book Micrographia:

'I took a good clear piece of cork, and with a Penknife sharpen'd as keen as a Razor, I cut a piece of it off, and thereby left the surface of it exceeding smooth, then examining it very diligently with a Microscope...I could exceedingly plainly perceive it to be all perforated and porous, much like a Honeycomb, but that the pores of it were not regular...these pores, or cells, were not very deep, but consisted of great many little Boxes...'

Thus, it was from the works of Hooke that the term 'cell' was applied to the units of structure found in all organisms.

It would be more than a hundred years later before the complexity of a cell would begin to be understood. Continued improvements in microscope technology permitted more detailed observation of the structures inside cells. Improved techniques for preparing slides of cells from living organisms aided in the discovery of additional structures within a cell. You have seen several of these tiny structures during this investigation. There are many other structures within a cell that are much too small to be seen even with today's best light microscope. Each of these tiny intracellular structures is called an organelle. The cork cells that Hooke observed were no longer living cells. They contained none of the organelles inside the cells that you have observed, only the dead, rigid cell wall remained.

Solving the mysteries found within the cell began in the early 1800's. Two German scientists Schleiden and Schwann, working independently, examined a variety of living things under the microscope. Using much the same procedure as you have, they concluded that all organisms are composed of cells and the substances their cells produce. What substances can you name that are produced by living cells?

About this same time, a French scientist, Dutrochet, concluded that the cell is the basic unit of structure in organisms. This means that a cell is the simplest and smallest piece of material that can be alive. No single organelle by itself can do all of those things required to be a living thing. To perform all that is needed to sustain life requires a set of organelles functioning together into a single unit which we call a cell. A few years later, a German scientist Rudolf Virchow added the idea that cells come from pre-existing cells. These three ideas--organisms are composed of cells, cells are the basic unit of structure, and cells come from cells--together make up what is known as the cell theory.

Your cells normally carry on all of the life processes. They take in food, break it down, grow, and reproduce, to name a few of their life processes. By the time you become an adult, your body will have almost 100 trillion cells, each performing its duty to keep you alive. Some examples of these are the cheek cells that provide a protective lining for the inside of your mouth, and the cells that make up your muscles which provide movement. Also, you have seen cells in plants. These are the units of structure that perform the processes needed to keep the plant alive.

What happens when a cell fails to function properly? When your cells malfunction, you may feel ill. If your cells deteriorate, you appear older. Many biologists feel that a better understanding of the cell will lead toward solving the problems of disease and aging.

We've come a long way since Hooke observed and named cells. The use of the electron microscope has opened new horizons in cellular research. With the electron microscope, you can magnify cellular structures up to 200,000 times. What cell structures were you able to identify from your studies? Using the electron microscope, scientists are gaining information on cell structures that you could not see: Golgi bodies, lysosomes, microtubules, mitochondria, endoplasmic reticula, ribosomes, and cell membranes. These and other organelles enable cells to recycle materials, build materials and produce energy, among other things. Research into these structures and their roles within the cells continues to offer insights into many of the secrets of life.

Today, many scientists and physicians continue the research of the intricate make up of cells. Others are looking at the way in which the cells of an organism work together to perform certain life processes. Recall the cheek cells you observed. These were just a few cells of the thousands that form the lining of your cheeks. A group of cells that are similar in size and shape and that work together to perform a particular process is called a tissue. Your body has many different kinds of tissues, each type performs a special task. As you continue your study in biology, you will learn more about other types of tissues such as cartilage, bone, fat, nerve, and blood.

INVESTIGATION #7: CELLS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Units of Life

1. Why did Robert Hooke use the term 'cell' to describe what he observed?
2. Why has it taken over 200 years to discover most of the organelles?
3. Why can't organelles be considered as the basic unit of structure for living things?
4. What three ideas make up the cell theory?
5. Define a tissue. What different types of tissue would you expect to find in your thumb?

INVESTIGATION #8: CELL TRANSPORT

Name _____
Section _____ Date _____

INTRODUCTION

Each cell must take in food and water. Cells must also dispose of waste materials made by the cell. How do these substances get into and out of the cell?

EXPLORATION

Cell Membrane Model

You have previously used Lugol's Iodine solution as an indicator for starch. In this activity you also will use an indicator solution called Benedict's Reagent which will show the presence or absence of sugar.

1. Place a dropperful of water in a labelled test tube. Add 10 drops of Benedict's Reagent to the test tube.
2. Place a dropperful of glucose (sugar) solution in a labelled test tube. Add 10 drops of Benedict's Reagent to the test tube.
3. Place the two labelled test tubes in a boiling water bath for 10-15 minutes. Record your results in the chart below.

Table 8-1

Material	Before Boiling	After Boiling
Water + Benedict's Reagent		
Glucose + Benedict's Reagent		

4. What color change indicates the presence of glucose?

5. Fill one beaker with 100 ml. of water.
6. Obtain a piece of dialysis tubing. Rub it between your fingers or blow in the ends to open. Twist and tie the tubing securely at one end.
7. Fill the dialysis bag with 5 ml. glucose solution and 5 ml. starch solution. Twist and tie the other end securely. Rinse the outside of the tubing thoroughly.
8. Place the tubing into a beaker with 100 ml. of distilled water. Add 20 drops of Lugol's Iodine to the water in the beaker. Record observations on Table 8-2 at the start and after 15-20 minutes of the experiment.

Table 8-2

	Initial Observations		Observations After Waiting	
	Inside Tubing	Outside Tubing	Inside Tubing	Outside Tubing
Materials				

9. Complete Table 8-2 by testing the solution outside the dialysis tube with Benedict's solution. What does the test indicate?

10. What color change took place inside the tube?

INVESTIGATION #8: CELL TRANSPORT

Name _____
Subject _____ Date _____

THE IDEA

1. How can you detect the presence of the simple sugar glucose?
2. What happened to the glucose that was in the dialysis tube?
3. What happened to the iodine solution outside the tube?

What evidence do you have to support your answer?

4. Summarize your answers on Table 8-3.

Table 8-3

What substances moved through the tubing?	What substances did not move?

5. What idea do the data allow you to state about the movement of materials across the cell membrane?
6. What characteristics of the cell membrane (dialysis tube) might explain why all materials do not pass through the membrane?

INVESTIGATION 88: CELL TRANSPORT

Name _____
Subject _____ Date _____

EXPANSION OF THE IDEA

Osmosis

1. Set up the apparatus as directed by the teacher. Draw and describe the osmometer apparatus.

Table 8-4

At Start	At the Conclusion

2. Mark the water level on the tube.
3. After 30 minutes compare the level of water in the tube to the original mark. What difference did you note?

4. Obtain two beakers. Fill one beaker one-half full of distilled water and the other beaker one-half full of NaCl solution. Label each beaker. Use a cork borer to obtain two identical cylinders of potato. Measure the length of the cylinders at the start. Record their lengths in Table B-5. Place a potato cylinder in each beaker. Allow the beaker and contents to stand for 15 minutes. Blot the cylinders dry, then measure the length of each and observe their stiffness and texture.

Table B-5

Cylinder	Length at start	Length after 15 minutes	Stiffness and Texture after 15 minutes
potato in distilled H ₂ O			
potato in NaCl			

5. What happened to the length of the potato in the distilled water? NaCl solution?
6. Compare the stiffness of the potato before placing it in the beaker with the texture and stiffness after treatment: distilled water; NaCl solution.
7. What do you think your data mean?

INVESTIGATION #8: CELL TRANSPORT

EXPANSION OF THE IDEA

Readings: The Cell Membrane

Prior to the use of the electron microscope, biologists believed that the cell membrane was a thin, single layer similar to a balloon. It surrounded the contents of the cell and protected the cell from its environment. At the same time, such things as water, food, and oxygen were able to pass into the cell while carbon dioxide and other waste products could pass out of the cell. But, how? Biologists knew what things were passing across the membrane, but could not explain how this was occurring.

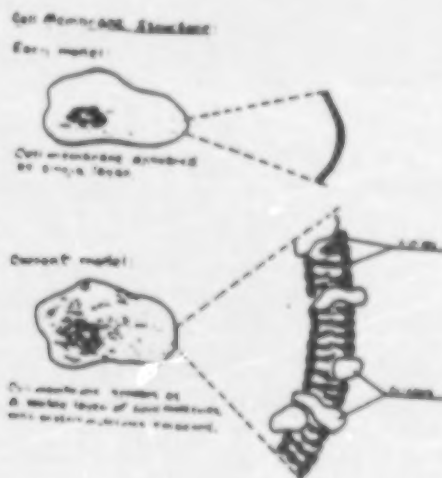
Since biologists could not actually observe the membrane in action, they constructed a model. They used the model to represent what they thought was happening. A model is a picture of all of the available knowledge about a particular structure. An early model of the cell membrane showed it as having tiny pores or holes. The cell membrane was thought to work similar to our skin. Our skin contains pores which allow sweating, yet protects the underlying tissues by preventing dust particles from entering. This model helped us to begin to understand how the cell membrane works. Recall the cell membrane model that we used earlier. It was made of a porous material (dialysis tubing). What evidence indicated that pores in the dialysis tubing are present? Could you see the pores? Why did only the sugar molecules and not the starch molecules pass through the pores of the dialysis tubing? When a membrane has a structure which allows some types of materials to pass through but not others, it is said to be semi-permeable. If it allows all types of things to pass through, it is said to be permeable. Recall that the dialysis tubing containing the sugar-starch solution was first placed in the container of pure water. The concentration of sugar was higher inside the membrane than outside. This condition caused some of the sugar to diffuse through the membrane into the surrounding water. Of course, water also may diffuse through a semi-permeable membrane.

During the potato experiment, the effects of water molecules diffusing into and out of the potato cells were observed. When water diffuses through a membrane, it is called osmosis.

Even though the action of the cell membrane could not be observed, these earlier models provided some ideas about how the cell membrane works. More accurate information about the cell membrane has recently become available.

Pictures of the cell membrane taken at extremely high magnification by the electron microscope show details of the membrane never before possible. New information about the kind of materials that make up the cell membrane is being discovered through chemical analysis. It is now known that the cell membrane is made up of two layers of fats or lipids, with numerous protein molecules scattered among the fat layers. Many of the proteins are embedded in the fat layers. When the cell is alive, the protein molecules in the membrane can change position as conditions change. Based upon this new information, a more accurate model of the cell membrane has been constructed (see diagram).

Earlier Model



Current Model

But, how does the cell membrane work? How can the cell obtain the right amount of each type of substance needed? Also, the cell must eliminate those waste materials such as carbon dioxide (CO_2) that accumulate inside its cytoplasm.

Have you ever tried to mix oil (a lipid also) and water? If so, you found that they don't mix. Most substances, such as sugars and salts, that move into and out of cells do mix with water. Most of the cell membrane is made up of lipids. How can those substances dissolved in water enter or leave through the cell membrane? The answer involves the proteins in the membrane. Most proteins mix easily with water! It is those proteins that allow dissolved substances to pass through the membrane. In a sense the proteins form the "pores" through which these substances diffuse. The pores formed by the proteins are extremely small. This is why substances must be dissolved to be able to pass through the membrane.

There are some substances such as fats, oils and alcohol that can dissolve easily in lipids. These types of substances use a different pathway to enter or leave the cell. Alcohol, for example, can dissolve in and be absorbed through the lipid layers of the cell membrane.

There are several factors which determine when molecules will diffuse through the protein or lipid parts of the cell membrane. Keep in mind that when a cell is alive the conditions both inside and outside the cell are continuously changing. As a cell uses up sugar the concentration of sugar inside becomes less than outside the cell. Increased activity by the cell causes it to produce increased amounts of carbon dioxide in its cytoplasm. And, of course, after eating a meal, the various food molecules absorbed into the blood increases their concentration. Certainly the concentration of a substance both inside and outside the cell affects diffusion of the substance through the cell membrane. The ability of the substance to dissolve in water or lipids also affects its diffusion through the cell membrane. In addition, the size of the separate particles of the substance affects its diffusion through the cell membrane. Since the particles of a substance must pass through either the proteins or the lipids, they must be as small as the proteins or lipids in the membrane.

As we have seen by the evidence of modern research, the cell membrane is a complex structure. When the cell is living, its membrane can change the arrangement of the proteins and lipids. This ability allows the membrane to change its permeability to different substances at different times. A cell membrane may be more permeable to sugar molecules at certain times by rearranging some of its proteins.

Although this new model of the cell membrane provides a better understanding of how things pass into and out of a cell, it does not answer all of the questions. Why can healthy cells keep out some poison substances but not others? Why can agents of disease such as viruses sometimes penetrate the cell membrane and at other times are kept out? Only when we can understand the structure and abilities of the cell membrane will we be able to answer these and other questions. Continued research may enable us to construct a more accurate model of the cell membrane and apply the new knowledge to problems such as disease, cancer and aging. One example of applying this knowledge is the kidney dialysis machine. This machine is constructed of materials which take over the job of the kidney cells by filtering harmful substances out of the blood. Many other equally important applications are currently being researched.

INVESTIGATION 88: CELL TRANSPORT

Name _____
Subject _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: The Cell Membrane

1. What is a semi-permeable membrane?
2. Thousands of people living today must spend several hours each week hooked up to a kidney dialysis machine. The cells of a healthy kidney filter out many harmful substances which accumulate in the blood. If the cells of the kidney are unable to filter these substances, the person becomes seriously ill and may die. How does the kidney machine remove most of the harmful substances from the blood?
3. Describe how modern technology has increased our knowledge of cells.
4. What three factors affect how substances are able to pass through a cell membrane?
5. How does the membrane of a cell become more permeable to a substance?

INVESTIGATION 89: CIRCULATION

Name _____
Section _____ Date _____

INTRODUCTION

A single-celled organism can readily diffuse needed materials and wastes through the cell membranes. Cells of more complex organisms also obtain nutrients and eliminate wastes. How can cells within an organism get rid of waste materials and obtain needed nutrients?

EXPLORATION

Heart Sounds and Exercise

1. While sitting, measure and record your heart beats with a stethoscope. What did you hear?
2. While sitting, measure and record your neck pulse or your wrist pulse for one minute. Record your results on Table 9-1.

Table 9-1

Name	Pulse, Sitting, Neck or Wrist	Heartbeat Stethoscope

3. Exercise for at least 5 minutes or until you are breathing hard. Measure and record your neck pulse as soon as you stop exercising; 3 minutes after exercising; 9 minutes after exercising; 15 minutes after exercising. What happens to your heart rate after you exercise?

Table 9-2

Name	Neck Pulse (Sitting)	Minutes After Stopping Exercise				Recovery Time
		0	3	9	15	

INVESTIGATION 89: CIRCULATION

Name _____
Section _____ Date _____

THE IDEA

1. Calculate the class averages and record the data on Table 9-2.

Table 9-2

	Average Sitting Pulse	Average After Exercise Pulse	Range
Class			
Boys			
Girls			

2. What variables might affect the heart rate?
3. What do the data allow you to state about the action of the heart?

INVESTIGATION #9: CIRCULATION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Fishtails

1. Gently wrap a goldfish in a wet paper towel or cotton, but leave the tail uncovered. Place the fish in a petri dish. Wet the tail and the bottom of the dish. Add a few drops of water every two or three minutes to keep the tail moist. (Do not keep the fish out of the water longer than 5 minutes.)
2. Place the dish on the stage of the microscope so that the light passes through the thin tissue of the fish's tail. Using low power, observe the vessels in the fish's tail.
3. Compare and describe the rate of blood flow in several blood vessels.
4. Describe any differences you observe in the blood vessels.

INVESTIGATION 89: CIRCULATION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Blood Stains

1. Obtain a drop of blood as described by your teacher. Place the drop of blood on one end of a clean slide.
2. Holding a second slide at a 45° angle, touch the edge of the drop of blood, then move the second slide across the top of the first slide. This will spread a thin film of blood over the surface of the slide.
3. Place the slide over a jar and add several drops of Wright's stain to the blood smear. Allow to stand for 2 minutes.
4. Using a medicine dropper, add enough drops of distilled water to rinse off most of the Wright's stain. Allow the slide to stand for 3 minutes.
5. Dip the slide in distilled water to remove any remaining stain.
6. Set the slide on a paper towel with the smear side up and allow the slide to dry. You may fan the slide to hasten drying.
7. When the slide is dry, observe the blood smear under low and high power magnification. Draw the different blood cells that you observe.

Blood Cells

Magnification _____X

8. Which kind of blood cells are the most numerous?

9. In what ways did the white blood cells appear different from the red blood cells?

10. Why do you think blood contains different kinds of cells and other substances?

INVESTIGATION #9: CIRCULATION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Heart Dissection

As the class discusses the heart, locate each part on the animal heart and label the drawing.

Figure 9-1



1. Position the animal heart as in Figure 9-1. The blood vessels enter the heart on the posterior side. Place the posterior side down with the narrow end (apex) pointing toward you.
2. Locate and examine the large blood vessels emerging from the top of the heart. These are the arteries and veins that carry blood to and from the heart. How is the tissue of the blood vessels different from the heart muscle?
3. Locate the ear-like flaps at the top of the heart. These are the atria, the upper chambers of the heart. The lower part of the heart consists of two chambers called ventricles.

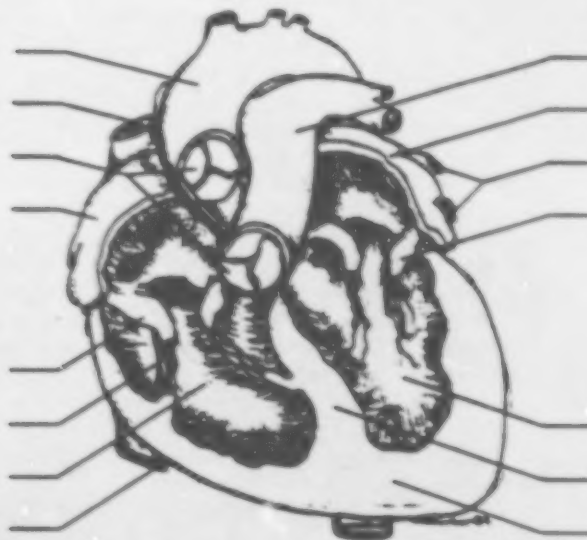
USE HEART #1 PROVIDED BY THE TEACHER FOR THE FOLLOWING OBSERVATIONS. THE CHAMBERS ON THIS HEART HAVE BEEN OPENED.

4. Open the incisions made by your teacher with your fingers to examine the atria and ventricles. Which are the largest of the chambers?
5. Compare the thickness of the walls of the atria to the walls of the ventricles. Which has the thickest wall?
6. Compare the thickness of the walls of the ventricles. Which has the thickest walls?
7. Find the right ventricle. Run your finger or a probe upwards along the wall (septum) that separates the lower chambers. Where does the probe exit the heart?
8. Find the left ventricle. Run your finger or a probe upwards along the septum. Where does the probe exit the heart?

RETURN THE HEART TO YOUR TEACHER AND EXCHANGE IT FOR HEART #2. THIS HEART HAS BEEN PREPARED SO THAT YOU CAN STUDY THE ACTION OF THE VALVES.

9. Find the right atrium and pull back the cut walls of the chamber. The three white flaps of material make up the atrio-ventricular (AV) valve. Slowly pour water through the valve into the ventricle. What happens to the valve as the ventricle fills with water?
10. Find the aorta. It has been trimmed so that you can see three half-moon shaped flaps of tissue. These form the semilunar valve. Pour water into the left ventricle until the valve closes. Squeeze the left ventricle with a quick motion. What happens to the semilunar valve?
11. Gently pour water onto the semilunar valve. What happens to the valve?
12. What do your observations tell you about the function of the valves of the heart?
13. Use arrows to trace the flow of blood through the heart on Figure 9-2. Label the structures as the blood passes through the heart.

Figure 9-2



INVESTIGATION #9: CIRCULATION

EXPANSION OF THE IDEA

Readings: Problems of the Heart

For years, heart diseases have been the number one adult killer. With the advances of modern medicine the death rate due to heart problems is decreasing. Just think, if your grandparents had heart trouble there was no open heart surgery to help. Today, heart surgery is a common occurrence. Now even mechanical hearts are a possible solution to a heart problem.

There are many types of heart problems that can occur. Let's analyze some of them, now that we have studied the circulatory system. Some people are born with heart problems. These problems are called congenital heart defects. During the development of some fetuses, certain structures that comprise the heart or the blood vessels may not form properly. Sometimes the fetal openings in the septum separating the right and left sides of the heart do not close properly at birth. Occasionally the pulmonary artery or valve is so narrow that little blood can get to the lungs. Congenital defects may result from diseases such as measles or may result from inherited characteristics.

Childhood diseases may result in heart problems. If a sore throat is caused by streptococcus bacteria, rheumatic heart disease may occur. If not treated, the strep bacteria produce a toxin. The toxin causes stiffening and wearing in the area of the left atrio-ventricular (mitral) valve.

Adults run the greatest risk of other heart diseases. However, many habits begun early in life may affect the health of your heart as an adult. Diet preferences and lack of proper exercise may contribute to a condition known as arteriosclerosis. This disorder of the arteries is caused by a buildup of cholesterol, a fat, and calcium deposits within the arteries. These deposits narrow the passages through which the blood must flow. If arteriosclerosis occurs in the arteries that supply blood to the heart muscle, a heart attack may occur. When arteriosclerosis appears in the arteries leading to the brain, a stroke may occur.

Hypertension is another disorder which adversely affects the heart. Commonly known as high blood pressure, hypertension is caused by a number of factors. Improper diet, obesity, and smoking are believed to be major factors linked to hypertension. Also, chronic emotional stress has been shown to be a contributing factor. Today drugs are available to help keep blood pressure under control. If untreated, hypertension may cause heart failure, stroke, kidney failure, or eye damage. Good eating habits and regular exercise help to reduce the chances of developing either hypertension or arteriosclerosis.

Often chest pains, shortness of breath, and swelling of the feet and legs warn of an approaching heart attack. If these warning signs are not heeded, a serious heart attack may occur. The problem may be with one or more of the arteries which supply the heart muscle with fresh oxygenated blood. The artery may be blocked by a blood clot or deposits of cholesterol. If left untreated, the decreased blood flow prevents some parts of the heart muscle from receiving enough oxygen and food to keep pumping. If the warning signs are heeded in time, a doctor may be able to dissolve the blockage before the heart muscle is damaged.

Modern medicine continues to make advances in the treatment of heart problems. Drugs that lower blood pressure and cholesterol levels have been used as effective weapons against hypertension. Newer drugs are showing promise in dissolving blood clots. Dissolving of some types of clots may soon be as easy as taking an antibiotic. Bypass surgery and inflatable balloon catheters have been developed for use in correcting damaged or clogged coronary arteries. During bypass surgery, a section from a vein in the leg is removed. The removed section of vein is connected to openings that are cut on either side of the damaged coronary artery. Blood flow occurs through the section of vein travelling around or "bypassing" the damaged part of the coronary artery. In some cases, clogged arteries may be reopened by using the inflatable balloon catheter (a thin hollow tube). In this method, the balloon is inserted up through the tube into the damaged artery. When the balloon reaches the clogged area it is inflated. As the balloon opens up, the diameter of the artery is enlarged. Scientists currently are looking into the use of a laser beam that could be directed through a catheter into the clogged artery. The laser beam would burn away the obstruction. Other advances include heart transplants. Some disadvantages of this method are lack of donors and rejection of the heart by the body. When a patient receives a transplant, the body often attacks this "foreign tissue" in much the same way as it attacks invading bacteria.

Current research is developing new materials used in the construction of artificial (mechanical) hearts. These advances and current research are offering new hope for heart failure victims. Yet, each person can decrease the chances for heart problems. Easing stress, watching your diet, not smoking, and aerobic exercising, will help ease the strain on your heart and blood vessels.

INVESTIGATION #9: CIRCULATION

Name _____
Date _____ Section _____

EXPANSION OF THE IDEA

Reading Questions: Problems of the Heart

1. Describe a congenital heart defect.

2. Why should parents not think of "strep-throat" as a minor illness?

3. What methods are available for treatment of clogged coronary arteries?

4. What things can be done to reduce your chances of having problems of the heart?

INVESTIGATION #10: CALORIES

Name _____
Section _____ Date _____

INTRODUCTION

Recall from the previous investigation that the blood of your circulatory system carries food to each body cell. What is in the food that the cell uses?

EXPLORATION

Burning Foods

1. Each lab group will be assigned two foods to burn. Obtain one of the food sources to be tested. Place 20 ml. of water in a test tube.
2. Place the thermometer in the water. Allow the thermometer to sit for about three minutes.
3. Secure the food sample to a dissecting needle. Place a pie plate underneath the sample in case it should fall. Record the initial temperature of the water in Table 10-1.
4. Hold the food sample in a Bunsen flame until it ignites. Immediately place it under the test tube so that the heat from the burning food warms the water. Allow the food to burn completely as you hold it beneath the test tube. If it goes out due to a draft, light it again.
5. Record the water temperature every 30 seconds from the beginning of the burning until the food has completely burned and the temperature ceases to rise.
6. Follow the same procedure with a second food source, using a clean test tube and fresh water.

Table 10-1

Temperature of the Water in °C

Minutes : Seconds

Food	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00

INVESTIGATION #10: CALORIES

Name _____
Section _____ Date _____

THE IDEA

Plot the data from "Burning Foods" on the graph.

Temperature

°C

40

35

30

25

20

15

10

5

0

0

1

2

3

4

5

Time : Seconds

1. What happened to the temperature of the water in the test tube when each sample was burned?
2. What food burned the longest?
3. What food was the hardest to ignite?
4. What must food have in it to heat water?
5. What idea do the data allow you to state about burning foods?

INVESTIGATION #10: CALORIES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Problem: Dieting

1. Record the items that you eat for one day. Record the type of food present (i.e., protein, carbohydrate, fat) and the size of serving. If questions arise, make an educated guess as to food type. Use whatever sources your teacher provides to estimate the number of calories.

Table 10-2

Daily Diet Chart

Date: _____		(Check Type of Food)			
Food	Approximate Size of Helping	Approximate Number of Calories	Carbo- hydrate	Protein	Fat
Breakfast					
Lunch					
Dinner					
Snack					

2. What is your total calorie count for the day?
3. Explain whether or not you think your diet is balanced and why.

Gender	Daily Calorie Count
--------	---------------------

Gender	Daily Calorie Count

- 90 -

INVESTIGATION #10: CALORIES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Problem: Calories in Action

1. Examine the chart below. It tells you the approximate number of calories used for certain activities.

Activity	Calories Used
Reclining.....	80 cal/hr
Walking.....	310 cal/hr
Bicycle Riding.....	490 cal/hr
Swimming.....	670 cal/hr
Running.....	1165 cal/hr

Use the above chart to solve the following questions. Show your work.

2. The average adult calorie intake is about 2,500 calories. Would this be enough for someone who runs for two hours per day? Explain your answer.
3. Mack sat around the house all day. How many calories per day would he need to maintain his weight?
4. On a bicycle tour a student cycled for 10 hours/day. How many calories did he/she require per day? What foods should this student eat?
5. To lose weight many doctors will place their patients on a 1,000 calorie per day diet. One girl, Lotta Kalory, decided that she would stay within her 1,000 calorie limit by drinking three malted milks (330 calories each). Discuss the implications of her diet.

INVESTIGATION #10: CALORIES

EXPANSION OF THE IDEA

Readings: Food, Glorious Food

Some of us eat to live, while others live to eat, yet no organism can live without food. To more fully understand this, you will need to know what kinds of foods exist, and in what ways your body uses each type.

After food is absorbed into the cells of your body, much of it is chemically burned. This is a somewhat different way than it burns outside your body. Imagine what would happen if the food was burned in the same way as it is outside the body. When burned inside your cells, most of the energy is released not as heat but as chemical energy. This energy is used by the cells to do their work.

A term used to refer to all of the work that goes on in the cells of an organism is metabolism. Recall what living things can do that non-living things cannot. These are metabolic processes. Food is required for all of those processes, especially for growth in children. A deficiency may slow down or stop growth altogether. Although mature animals may have stopped growing, they still require food for the repair and replacement of body parts. Of course, animals need to eat for many other reasons, such as to supply the energy used in movement.

People throughout the world vary greatly in the types of food they eat. The food we eat is determined largely by our climate and the economics of the region. Regardless of what the local food may be, a healthy diet must contain carbohydrates, fats, and proteins. Also, water must be included since so much is lost and needs to be replaced on a daily basis. Proteins and fats are essential for the growth and repair of the body's cells. Carbohydrates provide most of the energy used to power the cells metabolism.

Throughout this investigation we have seen that the minimum daily input of calories varies with climate, gender, body weight, individual physiological differences, and daily physical activity levels. We have seen that the average adult requires approximately 2500-3500 calories (actually kilocalories - kcal) per day. Examine Figure 10-1 to see how the distribution of the daily caloric intake varies throughout the world. Two-thirds of the world's population receive barely enough food energy to maintain their needs. Into which category do you think people in the United States fall?

Figure 10-1

Daily Caloric Intake of the World Population

Kcal	Under 2200	2200-2700	over 2700
percent of world population	66%	22%	22%

While most of the poor people in the world are malnourished, the wealthier people tend to eat too much and become overweight. People in the affluent nations indulge in high calorie diets that are rich in animal fat, salt, sugar, and processed foods. These diets are often low in fruits and vegetables. They have higher risks of suffering from diabetes, hypertension, cardiovascular diseases, and other health hazards related in part to overnutrition.

Much of this increase in caloric intake comes from eating too much sugar. How much sugar is too much? The average American consumes 128 pounds of sugar a year. Only a small proportion of it comes directly from your sugar bowl. Processed foods such as candy, cake and carbonated drinks are the largest sources. However, are you aware that there is some sugar in catsup and canned peas? Dieticians suggest that we eat more fruits and foods containing natural sugars. Natural foods contain smaller molecules to digest. They also supply the vitamins and minerals we need to live and grow.

Being overweight is caused by eating more calories than your body uses. The easiest way to lose weight is to cut down on your carbohydrate intake and to exercise regularly. But a word of caution is necessary before proceeding. Let's face it, many people are not happy with their body weight. Some people think that thin people are better than fat ones--that is, they are more beautiful, healthier, and live longer. Thin may be in, but fashion isn't always healthy. Oh yes, it's true that very obese people are at greater risk of developing high blood pressure, heart disease, and diabetes. But people with a family history of these disorders are among those that are higher risks.

Many people rely on the health-weight charts found in magazines, diet books, or posted on the wall of the doctor's office. Did you know that most of these charts are not based on any real medical evidence? More accurate health-weight charts have been developed by an unlikely source, the insurance companies. Their charts were originally developed to identify which policy holders were higher risk factors than others. Their concern was not what factors caused death and disease, but what factors were associated with early death.

The most representative study of the American population has been conducted on 5,200 men and women of Framingham, Massachusetts. This long-term study began in 1948, and is currently in progress. When people involved in the study die, the cause of death is carefully determined. Results to date may be found in Table 10-5.

Table 10-2

Life Expectancies

Weight	Men	Women
Light	High Death Rate	High Death Rate
Moderate	Little Correlation with Mortality	Little Correlation with Mortality
Heavy	High Death Rate	High Death Rate

These data suggest that the "ideal weight" is near the national average weight for men and women. One possible explanation may be that this group has "a little more to spare" if they become ill and can "burn off" some of the fat storage that they have. The height-weight charts are currently being revised.

Measuring caloric intake is only half of the "battle of the bulge." You have to estimate how much energy you are expending in the course of a day and see if your caloric intake needs to be adjusted according to those activities. Your bathroom scale honestly and impartially will measure your success!

When you live in a land of plenty, it is difficult to imagine the extent and effects of malnutrition. Hunger and malnutrition are both real and widespread in many lands throughout our world. One of the most promising developments for reducing this human problem is to chemically process whole fish, including the bones and internal organs, to yield a fine powder call FPC (fish protein concentrate). This FPC powder can be added to various foods. Underdeveloped nations can add it to enrich the flour used for baking. Another hope for the future is to develop successful methods of farming the seas. Algae and other plankton can provide enriched food sources. Even the blue whale, the largest marine mammal, can subsist entirely on a diet of plankton.

INVESTIGATION #10: CALORIES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Food, Glorious Food

1. In what metabolic processes are the nutrients from food used?

2. Dieting fads come and go. When choosing a diet, what should be considered?

3. What are some ways that malnutrition can be corrected?

INVESTIGATION #11: DIGESTION

Name _____
Section _____ Date _____

INTRODUCTION

The blood of your circulatory system carries food to each body cell. What do the cells of your body obtain from this food?

EXPLORATION

Food Tube

1. Obtain two pieces of dialysis tubing. Tie one end with string. Add 10 ml. of saliva and 10 ml. of water to one. Add 10 ml. starch and 10 ml. of starch to the other. Tie the other end of the tubing. Place each tubing set in 100 ml. of water in a beaker.
2. After the solutions in the tubing have set overnight, pour 1 ml. of the solution from beaker #1 into two test tubes labelled 1-A and 1-B. Pour 1 ml. of the solution from beaker #2 into two test tubes labelled 2-A and 2-B.
3. Run a starch test on 1-A and 2-A; run a simple sugar test on 1-B and 2-B. Record your results on Table 11-1.

Table 11-1

Beaker	Starch Test	Sugar Test
#1 Starch and Water		
#2 Starch and Saliva		

4. Which substances moved through the membrane?
5. Which substances did not move through the membrane?

INVESTIGATION #11: DIGESTION

Name _____
Section _____ Date _____

THE IDEA

Table 11-2

Class Data

Test Tube Contents	Starch Present		Sugar Present	
	Starch	Starch & Saliva	Starch	Starch & Saliva
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				

1. What does the dialysis tubing represent?
2. What does the water in the beaker represent?
3. What lines the food tube in the body?
4. What happens to food in the tube?
5. What idea do the data allow you to state about what happens to food and why?

INVESTIGATION #11: DIGESTION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Breakdown of Foods

1. Label and prepare nine test tubes so each is one-third full and contains the following:
 - #1-A - protein and water
 - #1-B - protein and stomach juice
 - #1-C - protein and pancreatic juice
 - #2-A - carbohydrate and water
 - #2-B - carbohydrate and stomach juice
 - #2-C - carbohydrate and pancreatic juice
 - #3-A - fat and water
 - #3-B - fat and stomach juice
 - #3-C - fat and pancreatic juice
2. Stopper all nine test tubes and place them in a warm place. Check for cloudiness in each and record your observations on Table 11-3.

Table 11-3

Food Source	A - Water	B - Stomach Juice	C - Pancreatic Juice
#1 Protein			
#2 Carbohydrates			
#3 Fat			

3. Write a general statement summarizing the results of Table 11-3.

INVESTIGATION #11: DIGESTION

EXPANSION OF THE IDEA

Reading: Why Doesn't the Digestive System Digest Itself?

Think of all the ways that we abuse our food tube or alimentary canal. Remember the hot sauce on the five tacos that you devoured for lunch or the breakfast you skipped this morning so that you could sleep an extra ten minutes? Besides, haven't you said that eating breakfast makes you nauseous? Isn't it a mystery how our food tube performs so efficiently in spite of how we mistreat it.

Why doesn't the digestive system digest itself? Just think of all the acid and pepsin secreted by the stomach alone. Several things protect the walls of the food tube (in particular, the stomach and the small intestine). First, the cells that line the food tube are coated with mucus. Touch your tongue to the inside of your cheek and you'll feel what I mean. This mucus protects the underlying cells similar to the way in which car wax prevents water from causing rust. Have you ever accidentally bitten your cheek? If a cold drink or a spicy food comes in contact with this damaged area, you may feel pain. But, don't worry, within a few days the cells should be replaced. The mucous layer, the cell membranes, and cell replacement help maintain the barrier between the contents of the tube and its underlying tissues.

If these protective mechanisms become temporarily inadequate, erosions or ulcers of the lining will occur. Ulcers commonly occur in the stomach, but they may be found in other locations. If stomach acid continuously flows back into the lower part of the esophagus or irritates the upper part of the small intestine (known as the duodenum) even a package of antacids won't help. When severe enough, the ulcer may damage the underlying blood vessels and become a bleeding ulcer. On occasion, the ulcer may penetrate the entire wall. This results in a leakage of the stomach contents into the abdominal cavity.

Ulcer formation means that the mucous barrier is broken. This exposes the underlying stomach tissue to the corrosive action of acid and pepsin. The causes that begin the breakdown of the barrier are uncertain. It is likely that many factors are involved: genetic susceptibility; the use of certain drugs; foods; smoking; and excess acid production are just a few of the possibilities. The aging process itself may slow down the replacement of cells. Although the actual role of stress in initiating ulcer formation remains uncertain, stress is recognized as a possible contributing factor. It may even be that the body's regulation of gastric juice production has malfunctioned. The pain experienced with ulcers probably is due to the stomach acid irritating the exposed nerve endings in the region of the ulcer.

Treatment of ulcers varies with their severity. If a bleeding ulcer cannot be stopped by medication, then surgical removal of all or part of the organ involved may be necessary. A change in diet may enable the injured tissue to heal itself without being subjected to more mistreatment. In the recent past, people with ulcers were told to drink Malox or milk before eating. These substances were thought to coat the ulcer so that the other foods or digestive juices did not irritate the open sore. However, current research has shown that milk and milk products cause an increase in acid secretion. A new drug now is used to slow down acid production. The patient is allowed to eat normally. The previously prescribed bland diet has been discarded. Bland diets are very low in fiber, the substance which regulates elimination.

What other common disorders affect the digestive system? At some point in their lives most people experience an upset stomach. Vomiting can be induced by overloading the stomach, various substances irritating the lining of the digestive system, simple nausea, or a stimulus applied to the back of the throat. Have you ever avoided a particular food or drink after a bad experience with it? Your body is actually sending you an important message. The nausea that usually accompanies vomiting may help to adapt the individual to avoiding the future eating of a particular food. Excessive vomiting can lead to large losses of fluid and salts. These fluids are normally reabsorbed by the large intestine. A large loss of fluid can cause severe dehydration. Dehydration can be life-threatening.

Although not a part of the alimentary canal, the liver produces bile that aids in digestion. The specific function of bile is to assist in the digestion of fatty foods. Bile is normally stored and concentrated in a sac between the lobes of the liver. Next, a small duct transfers it to the duodenum. There it mixes with the foods and digests the fats. A problem can occur in which the bile precipitates out and forms tiny stones called gallstones. When the stones are small they can freely pass into the duodenum. However, large stones will block the duct transferring bile to the duodenum. Severe pain results.

Some persons experience digestive problems if they are missing the enzyme required to digest a specific food. This is known as an enzyme deficiency disorder. Lactose, the sugar (carbohydrate) of milk is usually digested by the enzyme lactase. Occasionally, young children have an allergy to milk. Symptoms of this disorder include diarrhea, severe dehydration, bloating, and the production of large quantities of gas. The children are missing or producing insufficient quantities of the enzyme lactase. Infants with this condition must be fed a diet with no lactose. Some people gradually develop the enzyme; others are intolerant to milk for a lifetime. Just imagine all the foods that you would have to avoid if you were allergic to milk! This is only one example of an enzyme deficiency.

Common sense in eating and sleeping habits, taking life in stride and maintaining one's sense of humor will go a long way in preventing human "plumbing" problems. Your digestive system has a memory like an elephant--it will not forget at age fifty the way you treated it as teenager.

INVESTIGATION #11: DIGESTION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Why Doesn't the Digestive System
Digest Itself?

1. Describe how the stomach keeps from digesting itself.
2. What causes ulcers?
3. What other major types of disorders of the digestive system occur?
4. Plan one day of balanced meals for a high school student with a lactose enzyme deficiency disorder.

Breakfast	Lunch	Dinner	Snacks

INVESTIGATION #12: BREATHING

Name _____
Section _____ Date _____

INTRODUCTION

At times, all of us are conscious of the rhythmic movement of our chest as we breathe. How and why do we breathe?

EXPLORATION

Bottled Organisms

1. Prepare three test tubes as follows: fill two-thirds full with water; add 20-30 drops of BTB to each; stuff a cotton ball into each so that it rests just above the water line; add the organisms to two test tubes; leave one test tube without an organism; and stopper and label each test tube.

Organisms: 1A - no organism
2A - _____
3A - _____

2. Prepare another set of test tubes in the same manner as above, but add 20-30 drops of Janus Green B instead of BTB to each. Stopper and label the test tubes.

Organisms: 1B - no organism
2B - _____
3B - _____

3. After several days, record your observations of each test tube on Table 12-1.

Table 12-1

	Test Tube Number	Organism	BTB Test Tube	Janus Green B Test Tube
Color				
Changes				

4. What was the purpose of the test tubes without organisms?
5. What happens when you blow through a straw into BTB and water?

INVESTIGATION #12: BREATHING

Name _____
Section _____ Date _____

EXPLORATION

Breathing Machine

Describe and draw your "breathing machine" model.

INVESTIGATION #12: BREATHING

Name _____
Section _____ Date _____

THE IDEA

1. Record the class data on Table 12-2.

Table 12-2

Organism	Gas Given Off	Gas Taken In

2. Summarize the data you have gathered about the exchange of gases.

animals

plants

3. What idea do the data allow you to state about what happens when organisms breathe?

INVESTIGATION #12: BREATHING

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Breathing Exercises

1. Count and record the number of breaths you take for one minute.
2. Take a deep breath and hold it. Record the time that you were able to hold your breath. How did you feel?
3. While sitting, place a paper bag tightly over your nose and mouth. Breathe into the bag for one minute, then remove the bag. Immediately, count and record the number of breaths you take for one minute. As soon as you finish counting, take a deep breath and hold it. Count and record the time you were able to hold your breath after breathing into the bag.
4. Jog in place for two minutes. Count and record the number of breaths you take during the second minute of running. Then hold your breath and record how long you were able to hold it.

Table 12-3

		Holding Breath	After Bag Breathing		After Running	
Name	Normal Breaths per Minute	Time	Breaths per Minute	Holding Breath	Breaths per Minute	Holding Breath
Class Av.						

5. Choose one variable among students in your class that might affect breathing rate (gender or athletic training). Compare data from the different groups.
6. What happens to your breathing rate when too much carbon dioxide builds up in the paper bag?
7. List factors that might increase your breathing rate.
8. When do you think your breathing rate might decrease?

INVESTIGATION #12: BREATHING

EXPANSION OF THE IDEA

Reading: Keeping in Shape

Bob Beamon of the United States Olympic team cleared a record of 29 feet, 2 1/2 inches at the Mexico City Olympic Games in 1968. His records stands even after the 1984 Summer Olympics. In the 5,000 meter run, the olympic and world record time have improved steadily. In 1912 the winning time was 14:36.6, but in 1965 in Stockholm, Sweden, the winning time was 13:16.6. The Boston Marathon winner in 1897, clocked in at 2:55.10, while in 1967, the winning time was 2:15.45. What has caused these records to be shaved?

Many reasons may account for these trends. The conditions of the arenas, the weather, the altitude of the event, and the condition of the athlete may each be a contributing factor. Let's take a look at the conditioning of the athlete since it pertains to our study of biology. What do we know about physical training and our body?

Muscles require energy to work. Muscles that are exercised have more capillaries and receive more food and oxygen than muscles that are not active. Every time the heart muscle pumps, blood is sent from the right side of the heart to the lungs and from the left side of the heart to the body. Exercising increases the strength of the heart muscle so that more blood is pumped with each beat. The strengthened heart is able to beat fewer times each minute. Yet it sends more blood carrying food and oxygen to the body and returns the wastes to be eliminated.

Researchers have found that the hearts of long distance runners, swimmers, skiers and other endurance athletes statistically have larger hearts than their non-athletic counterparts. A larger, stronger heart may beat more slowly. This allows time for the heart to rest and to receive its food and oxygen for its own coronary blood system.

Yet, how fast can an athlete's heart supply the muscles with oxygen? When running, the stored energy in an athlete's muscle cells is used up. These working muscle cells require much energy to continue the running. At first, the energy is provided from the oxygen carried there by the blood. This is called aerobic respiration. When the oxygen demand is greater than the oxygen supply, the energy to continue running is produced without an oxygen supply. This is called anaerobic respiration. Following this, the athlete breathes heavily to bring a fresh supply of oxygen to the muscle cells. When enough oxygen is obtained to meet the demand, the oxygen debt is repaid.

The olympic athletes in endurance events who travelled to Mexico City (altitude 8,000 meters) in 1968 found that their running times were much slower when they first arrived. The shortage of oxygen at the higher elevation lowered their performances. After several days, they began to breathe faster and deeper. When checked by team doctors, the athletes showed an increase in red cells in their blood as well as in total blood volume. Their circulatory systems had begun to adapt to the high altitude in Mexico City. However, the winners of these endurance events had lived and trained at high altitudes for most of their lives.

Half a century ago, athletes trained only a few months each year. Their training involved little more than brisk walks and short runs. Since then athletes have shown that the body can change in response to abnormal demands. Their training continues throughout the year and its nature has changed enormously. Diet is important for the training athlete. Iron-rich foods are needed for hemoglobin production. A good long-distance runner increases the depth and frequency of his breathing. The increased oxygen must be transported to the respiring muscles where it is needed. For this reason, modern long distance runners concentrate on training methods which make heavy demands on the heart and circulatory system. They have found that just as other muscles get bigger and stronger through doing a lot of heavy work, so the heart gets large and strong if frequently called upon to work hard.

It has been found that by training, athletes can strengthen their hearts and increase the number of red cells which carry oxygen in the blood. They also can bring about other changes which increase the efficiency of their breathing and circulation.

Most of us aren't going to break any world's record in track, but being physically fit can be important to our health. Beginning to maintain a healthy heart, circulatory, and respiratory system as a teenager may lead to a longer, healthier life.

Before beginning a strenuous exercise program, you should have a physical checkup. A medical history, blood test, heart and lung observation, blood pressure reading as well as an eletrocardiogram (ECG) during rest and exercise should be evaluated. The ECG monitors the heart cells during every beat through metal electrodes taped on the chest and body. Healthy heart tissue conducts electrical impulses in a recognizable pattern. A stress ECG may detect problems of the heart that occur when it is working hard and fast.

Just how fast can your heart beat? After administering stress tests to many people, the maximum heart rate for all ages has been determined. In the stress test, the physician will stop you when you reach the limit for your age. Your recovery period, the time required for your heart rate to return to normal also will be monitored. The maximum heart rate is used to calculate a target program in aerobic exercising.

Concern for personal health and fitness has interested many people in aerobics. But what is aerobic exercising? Aerobic exercising increases the amount of blood in your body and increases the amount of oxygen-carrying hemoglobin in the blood. Because of these benefits, more oxygen is carried to the cells. Your heart hasn't had to pump as hard to get it there. In addition, aerobic exercising increases the efficiency of your lungs and the muscles that make your lungs expand and contract. The number of capillaries in your alveoli is increased. As a result of the increased number of capillaries, the exchange of oxygen and carbon dioxide occurs faster. Also, the heart's workload is reduced. The number of capillaries in your muscles increases with aerobic exercising. These additional capillaries allow more oxygen to reach the cells and faster elimination of wastes. There is evidence that blood vessels become more flexible. They are less apt to collect cholesterol deposits that may lead to arteriosclerosis.

During aerobic exercises your heart rapidly pumps blood through your arteries. When running, the blood supplies oxygen to the thigh and calf muscles of your leg. At the capillaries the oxygen is diffused into the cells. Through the one-way valves of the veins, the blood returns to the heart and lungs. Cool-down exercises are suggested after aerobic exercises to counteract the 'pooling' effect. The 'pooling' effect keeps blood in your legs. The much-needed fresh supply of oxygen is not rushed to your heart and brain.

What types of exercises are aerobic? Which are best to train your heart and lungs to work efficiently? Swimming, jogging, running, and bicycling are the best aerobic exercises. To qualify as an aerobic exercise, the activity must maintain a target heart rate for 15-30 minutes. The beneficial training effects will result if the activity occurs a minimum of four times per week.

Now that you know the ways in which your body benefits from aerobic exercise, let's all get into shape.

INVESTIGATION #12: BREATHING

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Keeping in Shape

1. What causes you to breathe rapidly after running?
2. Name three changes that occur in your body from a long term program of aerobic exercising.
3. What types of food would a training athlete need to eat and why?
4. Use the following formula to compute the minimum and maximum working heart rates to use as guidelines during an aerobic fitness class for a beneficial training effect to occur:

My Age is _____
My maximum target heart rate average is $220 - \text{Age} =$ _____
My resting heart rate is _____

Formula: _____ Maximum Target Heart Rate
(subtract) _____ Resting Heart Rate
_____ Answer A

(Multiply Answer A by .60 and by .80 to determine your minimum working heart range)

Answer A _____ X .60 = _____ Answer B

Answer A _____ X .80 = _____ Answer C

(add your Resting Heart Rate to Answer B and to Answer C)

_____ + _____ = _____ Minimum Working
Answer B Resting Heart Rate
Heart Rate

Divide by 6 to obtain
10 second heart rate _____

_____ + _____ = _____ Minimum Working
Answer C Resting Heart Rate
Heart Rate

Divide by 6 to obtain
10 second heart rate _____

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

INTRODUCTION

Crossing the street at a busy intersection can be very dangerous. To cross the intersection safely, you must receive information from your surroundings and decide when to cross the street. How do you receive the needed information?

EXPLORATION

Knees and Eyes

1. Sit down and cross your legs. Make sure the top leg is relaxed. Locate the kneecap of the top leg. Find the soft area just below the kneecap and just above the top of the leg bones. Use the side of your hand and strike this soft area below the kneecap. (Several attempts may be necessary before results are achieved. One strike and then a pause of several seconds is recommended before striking again.) Record your observations on Table 13-1.
2. Have your lab partner hold a sheet of clear material in front of the face. Crumple up a piece of scrap paper and toss it at the face. Carefully watch the eyes. Record your observations on Table 13-1.
3. Have your lab partner look directly into your face. Briefly shine a penlight directly into one of your eyes. You may need to repeat this several times. Record your observations on Table 13-1. Repeat the procedure, but this time observe what happens to the eye not exposed to the light. Record your observations on Table 13-1.

Table 13-1

Activity	Observations	
Knee Jerk		
Eye Toss		
Light in the Eyes:	Exposed Eye	Unexposed Eye

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

EXPLORATION

Taste

Place a clean Q-tip in the substances listed in Table 13-2. Taste each substance in the order listed. Rinse your mouth after each test.

As you test each substance, try to determine which area of the tongue registers the taste. Record your observations on Table 13-2.

Table 13-2

Substance	Location of Taste
Salt	
Sucrose	
Lemon	
Quinine	

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

THE IDEA

Table 13-3

Class Data

Test	Stimulus	Part of the body receiving the stimulus	Part of the body reacting to the stimulus	Sense Involved
1		knee		
2		eye (eyelid)		
3		eye (pupil)		
4		tongue		

1. What are the five senses?
2. What do you call the information received through your senses?
3. What idea do the data allow you to state?

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Balancing Act

Perform the following balancing acts with your eyes open then with your eyes closed: limit each act to sixty seconds.

	Eyes Open	Eyes Closed
1. Balance on one foot. How long could you stand?		
2. Balance on your other foot. How long could you stand?		
3. Balance with your right hand and right foot on the floor. How long could you balance?		
4. Walk on top of the rope with your shoes on. How far did you walk?		
5. Summarize the data you have gathered about balance and the sense of sight.		

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Eye Tests

1. Stand on the tape which is twenty feet away from the Snellen Eye Chart. Test one eye at a time with the other one covered. Record the last line readable. See the eye chart to record values.

Right Eye

Left Eye

--	--	--

2. Focus on the letter X below.

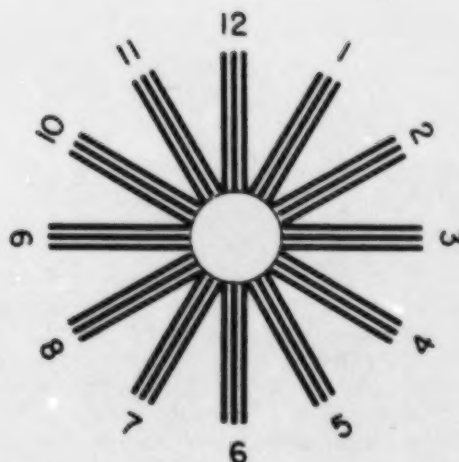
X

Close one eye and move the page up to your eye until the letter becomes blurred; then move it away until you get a clear undistorted image. Have your lab partner measure the distance from your eye to the page with a ruler. The closest distance at which the eye can see a clear undistorted image is the near point. Test the other eye also and record your results below.

Name	Eye	Distance of Clearest Vision
Class Average		

3. Stand on the tape which is 10 feet from the pinwheel charts and test each eye individually. Are all lines sharp and equally black? If not, record the appropriate numbers:

Right Eye	Left Eye



120

4. Evidence that a blind spot exists in each eye is demonstrated by using the test chart below.

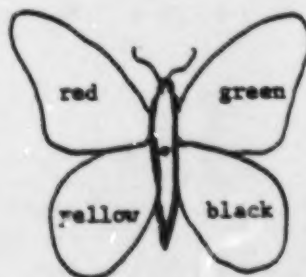


To test the right eye, one closes the left and stares at the plus sign with the right eye as the paper is slowly moved from about 18 inches toward the face. At first, both the plus and dot are seen simultaneously; but, at a certain distance from the eye, the dot will disappear as it comes into focus on the blind spot of the retina. Perform this test on both of your eyes. To test the left eye, it is necessary to look at the dot instead of the plus sign. Have your lab partner measure the distance from your eye to the test chart with a ruler. Record the measurements below.

Right Eye (cm)

Left Eye (cm)

5. Use colored pencils to color the labeled sections on the figure below. Stare at the dot in the center of the butterfly for one minute. Then stare at an unlined sheet of white paper. Observe the colors that you see in any afterimage. Describe the colors observed in the afterimage.



INVESTIGATION #13: RESPONSES

EXPANSION OF THE IDEA

Reading: Animal Senses

Over the dry plains, a red-tailed hawk sees a prairie dog and swoops down from its lofty vantage point. In a small cove, a black bass picks up the vibrations of a spinnerbait and changes course to intercept it. In a public hunting area, a whitetail buck noses the air, snorts nervously and bounds away before an orange-clad hunter appears over an upwind ridge. On a moonless, pitch-black night along a river, a young raccoon groping under a rock comes up with a crawdad for supper.

In each case the animal is using one or more of its five senses of sight, hearing, smell, taste, and touch. As long as we limit our comparisons to such higher forms as fish, fowl and mammals, animal senses are basically the same as our own, varying more in degree of sharpness than in kind. Whether you are a pure student of natural phenomenon or couldn't care less about anything which doesn't help fill your stringer or game bag, animal senses are of interest to you.

This is a lot of ground to cover, so let's stick with generalities in the categories of fish, fowl and mammals. Since vision, undoubtedly, is the most important of all animal senses, except to cave dwelling fishes and bats, this is the logical place to begin.

Sight

The two most important things an animal's eyes have to do are look for food and watch for enemies. For most critters, eyes placed on the sides of the head seem to be best suited to accomplishing both. While predatory fish have binocular vision (both eyes seeing toward the front, which allows depth perception) all fish, most birds and plant eating mammals have their eyes on either side of their heads.

Binocular vision, the ability to see in all three dimensions (height, breadth and depth), is possible only when the eyes are directed forward, as in such predators as bobcats, owls and man. This system produces overlapping images which are blended by the brain to help judge distance, a decided advantage to creatures which must catch prey to stay alive.

Fish. Fish eyes are efficient. Not all fish have the same ocular abilities, and not much is known about vision in some species. The largemouth bass, probably the most understood species, can serve as a measuring stick for the others. Bass can see quite well in clear water and can detect objects and movement above the surface, too. Bass also can see well in dim light and have good color perception. Scientists have concluded that bass see colors much the same as you or I would if we wore yellow-tinted glasses.

Birds. Birds normally are thought of as having sharp vision. The expression "eyes like an eagle" is self explanatory, and any hawk can see at least eight times better than we can. This is not because birds of prey have telescopic vision. They do have retinas (the inner lining of the eyes) tightly packed with light receptors, which gives the bird an incredibly sharper image. And, it is thought that all day-active birds possess color vision.

When one thinks of birds' eyes, the owl often comes to mind. The field of vision of the owl's two eyes overlap for about 70 degrees, much like human vision. However, what is normal for an owl is quite impressive by human standards. We have a certain amount of night vision unless the sky is pitch black, but some owls can see in light only one percent as intense as the minimum needed by humans.

Mammals. In general, mammals are short-sighted and color blind, depending more on smell and hearing to sample their environments. All mammals below higher apes and man are presumed to see everything in black, white and shades of gray, of which there are at least 500 shades. However, many of them have highly developed night vision.

This night vision is due largely to the presence of a reflective layer of cells beneath a nocturnal mammal's retina. This layer, called the tapetum, bounces dim light back through the retina and gives the mammal a double chance to use the light, letting it see at least twice as well as we can at night.

Hearing

Sounds are important in the animal world, for they often tell a predator that prey is approaching, and vice versa. Any moving object produces vibrations in the air or water, and it is these which animal ears interpret just as our own do.

Fish. A fish's ears have no external openings, but sounds are passed to them readily through the skull. Some fish probably hear better than others, and every angler worth his sneakers knows sounds can spook bass. Catfish seem to hear as high as 13,000 vibrations per second. Human ears, by comparison, hear up to 18,000 to 20,000 vibrations per second. Fish do a better job on the low end of the scale than we do, however.

Birds. The most interesting example of acute hearing among birds is found within the owl clan. In some species, the ear apertures are asymmetrical, or at different heights on each side of the head. This increases the time lag between the arrival of the same sound at each ear and gives the owl "binocular" hearing which helps the owl pinpoint the source of a sound.

Mammals. The dog family is a good example of well-developed hearing abilities. The high-frequency dog whistle, inaudible to us but quite plain to any canine, is the proof of this. Both wild and domestic cats have excellent hearing abilities, too, and use this to augment their sharp eyes in hunting. And, no deer hunter has to be told to sit quietly if he wants a chance at a deer. However, the most striking adaptation in hearing is the trademark of the bat.

All bats emit high-pitched sounds. Most bats emit short pulses of sound at frequencies up to 100,000 Hertz (vibrations per second), far beyond the aforesaid limit of human hearing. These pulses are about one-tenth of a second apart and are sent out in a conical beam. Any echo returning from an object is picked up by the bat's ears and its brain interprets this into an "image" as useful to the bat as vision is to other mammals.

Smell and Taste

The senses of smell and taste are important to most animals living on or near the ground. These are chemical senses and are considered separate in man. In animals, the distinction is more difficult to make.

Fish. Fish have a highly developed sense of smell, and in a great number of species this is the way in which they locate their food. The catfish's barbels are sensitive to dissolved chemicals, so this is primarily a smell adaptation. Other fish have blind sacs in their noses which have olfactory sensors and function as our noses do.

Birds. It seems highly unlikely that many bird species, if any, can smell. The ultimate proof of birds' lack of olfactory sensitivity lies with the great horned owl, which preys upon skunks without so much as a grimace over this mammal's potent odor.

Generally, it is believed that birds have a poor sense of taste. For example, a pigeon has only 50 to 60 taste buds on its entire tongue, while a rabbit has more on the order of 17,000 on its tongue. However, it is known that at least some birds can discriminate between foods through flavor.

Mammals. Most mammals have a good sense of smell, and for some species, smell may be the most important sense. This is especially true for such animals as coyotes and deer which have wet noses. All carnivorous mammals can follow a trail or find their prey by smell.

Even though there is much overlap in the senses of smell and taste in mammals, it would be a mistake for us to consider all examples similar to our own. In the first place, such comparisons are insulting to lower mammals. Secondly, many mammals seem to be attracted to smells we tend to regard as "putrid," and they eat with undisguised relish the carrion this attraction often affords them.

Touch

The tactile sense is often considered to be of little importance in the animal kingdom. Although it requires extreme proximity to whatever is being sensed and it is simple compared to vision, hearing or smell, it can be important.

Fish. Catfish, bullheads and carp, all of which often occupy turbid water, can use their whiskery barbels to locate food. However, the smell role these play probably far outweighs their value for feeling along the bottom. The lateral line on most fish actually is a refined sense for "touching" at a distance. Low end of the scale vibrations are sensed by these lateral lines, which are thought to be sensitive enough to pick up even a single tail beat of another fish from as far away as 50 feet.

Birds. When a woodpecker hammers a hole in a tree trunk, he uses his long, barbed tongue to find grubs and insects by touch. In certain birds, especially the snipe, woodcock and some ducks, the tip of the bill is served by nerves which give the birds a sense of touch there.

Mammals. Touch is useful to some animals in finding food or escaping from predators. The facial hairs of most mammals are specially sensitized. The best example, the long whiskers on a cat's muzzle tell it whether or not an escape hole will permit its body to pass through unscathed.

Touch is particularly important to the raccoon, as evidenced by its propensity for locating food by feel in water. Tests show the raccoon is most sensitive to touch or vibration. Sound is next in descending level of importance, and his night vision (which is at least twice as good as ours, remember) is least important to him.

All fish, birds and mammals react to their environments by obtaining and evaluating information about them. To do this, they rely on their five senses, and each species may have adaptations to suit particular needs. But, whether by an eagle's eyes, a jackrabbit's ears, a coyote's nose or a bobcat's whiskers, animals get their information as we do. Usually, the only real difference is that they do it a lot better.

Reprinted with permission from Outdoor Oklahoma, May, 1979, from the article by Mickey Brown, "Wild creatures perceive their environments much as we do...except they do it better."

INVESTIGATION #13: RESPONSES

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Animal Senses

1. While driving along a midwestern state highway on a sunny winter day, you see a red-tailed hawk perched on a fence post every few miles. Each hawk scans the grassland for a small rodent, reptile or bird. How is the hawk able to locate its prey as it sits perched on the fence?
2. Rabbit eyes are located on each side of the head. How might this vision be used to look for food and/or watch for enemies?
3. How does the hearing of owls differ from that of humans?
4. What evidence is there that birds do not smell well?
5. Give two examples to indicate the sense of touch being used by an animal.

INVESTIGATION #14: LOCOMOTION

Name _____
Section _____ Date _____

INTRODUCTION

The human nervous system enables each individual to respond to stimuli from the environment. Many of these responses require movement. How are animal bodies designed for movement?

EXPLORATION

Wings and Arms

1. Carefully remove the skin from the chicken wing.
2. Isolate one of the larger muscles and find the points at which it attaches to the bone. This structure is a tendon. How does the appearance of the muscle change near the bone?
3. While holding one end of the large bone, pull on one of the larger muscles. What happens?
4. Locate a muscle that causes the opposite reaction of the larger muscle you pulled. Where is the opposite muscle attached to the bone?
5. Place your lower arm on the table with your palm up. Place the fingers of your other hand on the middle of the top side of the upper arm. Slowly lift your forearm towards your shoulder, then slowly return your arm to the table. Describe what you feel as you lower and raise your arm.

6. Position your arm as you did before. Place the fingers of your other hand in the middle of the underside of the upper arm. Slowly lift, then lower your forearm. When your hand touches the table, gently press the back of your hand on the table. Describe what you feel.
7. Place your lower arm on the table with your palm up. Press the fingers of the opposite hand on the inner angle of the elbow. Make a fist, bend the elbow, and flex your upper arm muscle several times. Describe what you feel.
8. Using a probe, pull apart the muscle tissue of the chicken wing. In what direction do the muscle strands run?
9. Remove the muscle from the bones of the chicken. The point where two bones connect is a joint. Locate the joint of the wing. How does the appearance of the bone near the joints differ from the rest of the bone?
10. Cut through the knuckle, then break the large bone of the chicken wing. Describe the structure of the bone and any contents.
11. Using the materials provided by your teacher, construct a model of the arm in which the elbow bends much like your elbow. Draw your model and describe how it works.

INVESTIGATION #14: LOCOMOTION

Name _____
Section _____ Date _____

THE IDEA

1. What do bones do?
2. What do muscles do?
3. What do tendons do?
4. What do ligaments do?
5. Describe the arrangement of bones and cartilage in a joint.
6. Describe how muscles work in opposing pairs.
7. What idea do the data allow you to state about muscles and bones?

INVESTIGATION #14: LOCOMOTION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Bone Puzzles

1. Locate the following types of joints both on your body and among the bones provided by your teacher. Record your findings.

Table 14-1

Types of Joints	Locations on Your Body	Bone Groups
Moves all directions		
Moves in one direction (and back)		
Moves only slightly		
Does not move		

2. Describe the differences between the ends of the bones that make up each type of joint in Table 14-2.

Table 14-2

Moves all directions	
Moves in one direction	
Moves only slightly	
Does not move	

INVESTIGATION #14: LOCOMOTION

EXPANSION OF THE IDEA

Reading: Movement

Many of you have watched the world or olympic gymnastic competitions. What power and grace are exhibited by those superb athletes. In general, athletic competitions stress power, speed, and agility. The efforts of these outstanding athletes epitomize human movement. However, the ability to move our body is taken for granted by most of us. There is no apparent mystery to movement. There are, however, many kinds of organisms which cannot move from place to place by themselves. Indeed, moving is not a part of the nature of all living things.

What is it about movement that is so marvelous? Movement allows us to get from one place to another. Movement allows organisms to reach, stand, sit, walk, and breathe. But, why have some organisms developed these abilities, while others have not? Food gathering is an important factor. Those organisms that cannot produce food within their own tissues must obtain food from other organisms. Unless food is somehow brought to them, such organisms must get it for themselves.

There are other uses for this marvelous adaptation called movement. The ability to move serves equally well to escape being eaten. Without this ability, the life span of many organisms would be very short indeed! There would be too little time to grow, mature, find a mate, and produce offspring. The ability to avoid danger is certainly an essential factor for staying alive.

Most animals exist as members of a population, and therefore, have a means of communication. What does communication have to do with movement? We need only think about the variety of ways in which animals communicate. A honeybee, returning from a newly discovered honeysuckle vine, performs a complex "dance" which indicates the location of the honeysuckle to the other bees of the hive. A peacock flagrantly displays his elegant tail feathers to entice a mate. Consider the subtle wink passed between a girl and boy. There are countless other examples of communication behaviors. You have observed a few during the ecosystem investigations. Muscular movement is as intricately involved in communication as it is in food getting or escaping danger.

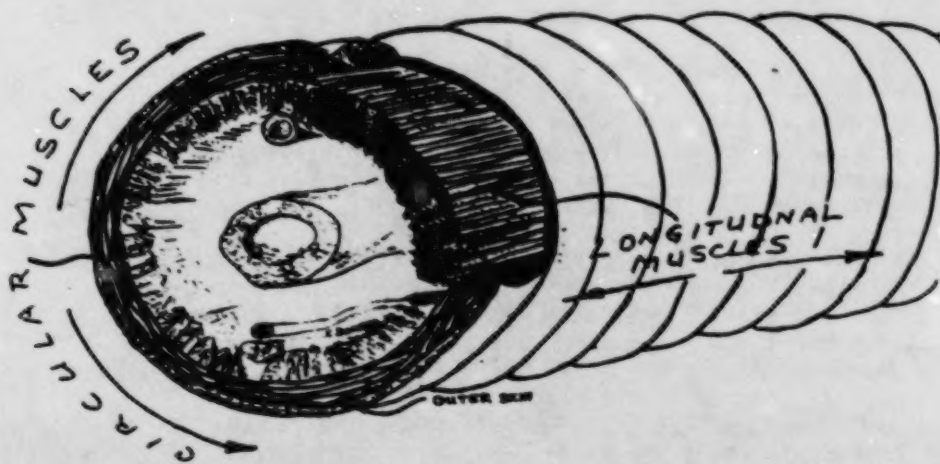
Humans use a variety of movements when communicating. Seeing, hearing, and talking are all a part of our communication behavior. Body movement, popularly known as body language, is a seldom considered, but important aspect of human communication. A slight change in the position of the mouth, hands or even the eyebrows can signal changes in the meaning of what we convey. In recent years, body language research has yielded evidence that we employ subtle changes to shade the meaning of our communication. These significant aspects of our ability to communicate are possible because of the ability to move.

How is movement made possible? What types of structures are found that endow an organism with the ability to move? The type of structures which enable movement are familiar to most of us. Surely, muscles and bones are required. But, what about organisms, such as bees and earthworms, which have no bones? To understand movement, many things must be considered.

A close examination of the muscles found in our body or those muscles of an earthworm or honeybee would reveal an important common design feature. Each part of an organism's body that moves has a set of muscles arranged in opposing directions. This arrangement is required because muscles only can contract and relax. Muscles cannot lengthen. Examples of this muscle design are the flexors and extensors in your forearm and the circular and radial muscles within the iris of your eye.



A similar design feature of a circular-longitudinal set of muscles enables the earthworm to crawl. It simply contracts the circular set in order to lengthen its body, then contracts the longitudinal set to pull itself together. This process is repeated, and allows the earthworm to crawl.



Opposing sets of muscles also exist in the legs of insects. Each leg is made of several segments with a movable joint in between. Unlike our body, there are no internal bones. A strong, stiff exoskeleton substitutes for bones. Within this exoskeleton, lie the opposing sets of muscles. These opposing muscles alternately contract and relax and allow the insect to walk or hop.



Joints in either the exoskeleton or endoskeleton enable the bones to act as movable levers. The design of a joint determines both the direction and distance in which the bones can move. For example, a ball and socket joint provides the greatest range of movement whereas a hinge joint limits the extent of movement. What movements are allowed by the ball and socket joint and the hinge joint?

Recall the last time your nose itched. Did you have to "tell" your fingers to begin scratching? Nerve impulses travelled through your body to the muscles of your fingers without your thinking about it. Some movements, such as throwing a ball, standing, or walking, require a conscious effort on your part. Breathing, digesting, and the beating of the heart are involuntary movements. Movement, both voluntary and involuntary, is controlled through nerve impulses. Nerve impulses, the contraction of muscles, the design of joints, and the rigid strength of skeletal tissue are all essential for that marvel of the human body we call movement.

INVESTIGATION #14: LOCOMOTION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Movement

1. Describe an example that you have observed in which movement of an organism was a means of communication.
2. Describe the details of what occurs when you raise your arm.
3. What are differences between voluntary and involuntary movement?
4. How do joints enhance movement? Give one example.
5. How do the circulatory and respiratory systems work in conjunction to cause movement?

INVESTIGATION #13: CELL DIVISION

Name _____
Section _____ Date _____

INTRODUCTION

Microscopic examination of organisms illustrate that each living thing is made of cells. Each cell of these organisms came from a pre-existing cell. How do existing cells produce new cells?

EXPLORATION

More Onion Cells

1. Each of the numbered microscopes around the room have been focused on one particular part of the onion root specimen. DO NOT MOVE THE SPECIMEN. Observe and draw the cells in the spaces provided. Make your drawings large enough to show details of the structures within the cell.
2. After you have completed the drawings of the cells, view the filmloop provided by your teacher. In your own words, describe what you see occurring. You may wish to add drawings of the process observed.

INVESTIGATION #15: CELL DIVISION

Name _____
Section _____ Date _____

THE IDEA

Table 15-1

	Drawings	Describe the changes that occur from drawing to drawing
Start		
Finish		

What idea do the data allow you to state about how new cells are produced?

INVESTIGATION #15: CELL DIVISION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Large and Small Cells

1. Obtain three different-sized agar blocks.
2. Place each block into a separate, labelled beaker. Cover each block with a solution of sodium hydroxide (Caution--handle with care) for 15 seconds. Pour off the sodium hydroxide and rinse the agar blocks with water.
3. Dump the rinsed blocks onto paper towelling. Cut each block in half and measure the depth to which each block has been stained. Record your observations on Table 15-2.

Table 15-2

Stained Blocks

Size of Block	Depth of Stain	Unstained Area
small _____ cm ³		
medium _____ cm ³		
large _____ cm ³		

4. In which block did the stain penetrate the most?
5. List several substances that cells need to live.
6. List the substances that a cell needs to pass out.
7. Why is the size of a cell important?

INVESTIGATION #15: CELL DIVISION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Planaria

1. Use a thin paintbrush to gently lift a planarian onto a microscope slide. Use just enough water to allow it to move around. Using a microscope or hand lens, observe and describe the planarian.
2. Using the procedures described by your teacher, make an incision.
3. Carefully transfer the planarian or each section of the planarian to a separate labelled petri dish. Cover each dish and return each in the designated area.
4. Observe the planarian over the next 7-10 days. Record any changes you observe during this period of time on Table 15-3.

Table 15-3

Date	Observations

INVESTIGATION #15: CELL DIVISION

EXPANSION OF THE IDEA

Reading: Carrots, Cloning, and Cancer

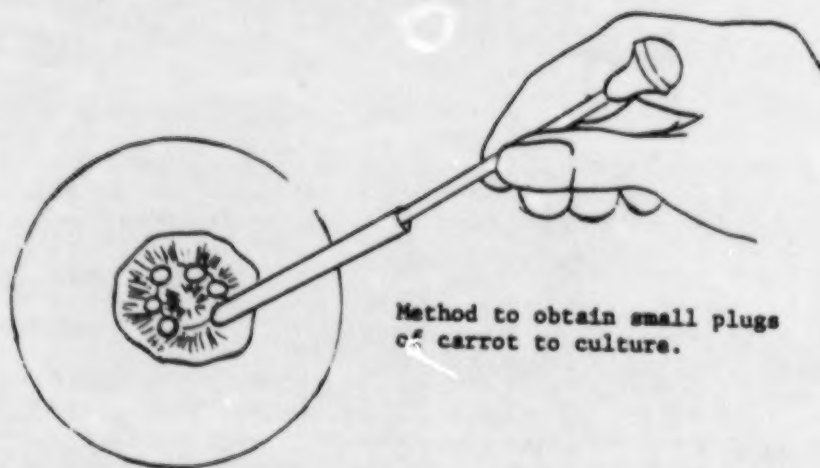
From our studies of cell division (mitosis), it should be apparent that daughter cells contain identical sets of chromosomes. Each cell should carry a complete set of chromosomes. These work as the blueprint to make a complete organism. Yet, all cells are not identical. The cells in our body have become different (differentiated). Our cheek cells do not look the same as our blood cells. Why not? How do they change?

When biologists need an answer to such complex questions, they turn to a simpler cell--the plant cell. Most of you are familiar with the carrot; the vegetable your mother always wanted you to eat. (She always said that it was good for your eyes!) Whether or not the carrot is your favorite vegetable, is not important to cell researchers. Experimentation with the carrot has led to discoveries adding to the study of cancer.

Consider the carrot; imagine removing a small piece from its root and maintaining it in a moist environment. New cells will be produced along the cut edge by the process of mitosis. Eventually the wound will heal and new cell production will cease. What starts and stops the process? The actual cutting of the carrot appears to switch on the mitotic process, and the healing of the cut seems to switch it off. What factor is acting as a switch to development?

In the early 1960's, the basic research into the problem was conducted by botanists. It is possible to start many new plants from the cuttings of one plant. But, how much of the original plant actually is needed? F. C. Steward and his colleagues began with this problem: was it possible to grow completely new plants from only a few cells of a mature plant? This research team hypothesized that if every cell in an organism has the same chromosomes, each must be capable of developing into a complete organism. Therefore, the correct conditions must be supplied.

Their first step was to learn what conditions will stimulate growth and development. Plant embryos develop in the seed. Plant embryos are nourished from special food found in the developing seed. This material is known as the endosperm. The solid material in the two halves of a bean seed is the endosperm. The endosperm of the coconut, which is the seed of the coconut palm, is a liquid. Steward used this liquid endosperm as nourishment for the carrot cells. Small pieces of carrot tissue were obtained using a thin cork borer. The small plugs of carrot cells were placed in Erlenmeyer flasks containing a growth medium that included coconut milk. The flasks were rotated to alternately bathe and expose the carrot pieces to the air. Great care was taken to prevent contamination by micro-organisms.



Although the researchers expected some effect from the coconut milk, they were not prepared for the dramatic results which occurred. The carrot tissue grew rapidly and in three weeks had multiplied in weight eight-fold!

The second step in this investigation involved rotating small pieces of carrot tissue in a special flask. Some of the individual cells separated. These free cells were placed in the same nutrient solution. At first the new tissue consisted of unspecialized cells. By cell division, cell enlargement, and cell differentiation, they became arranged into clusters of cells like carrot embryo. Some of these clusters developed small roots. When transferred to an agar medium containing coconut milk, a green shoot with leaves formed opposite the roots.

Eventually these plants were moved to soil. Now Steward and his colleagues had grown many carrot plants with roots, stalks, leaves, and flowers; each developed from a single cell. These were the first cloning experiments, that is, the growing of many individual organisms from the cells of one!

carrot plant



produced by culture method.

These experiments suggested that a "blueprint" for growth and development is carried by the chromosomes of a single cell. The presence of a substance or substances can switch on the chromosomes to direct the development.

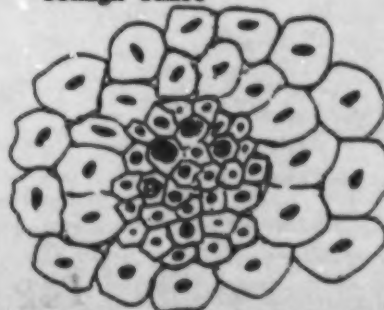
Consider the implications of these results. Can we take cells from someone's fingertips, culture them, and produce multiple copies of the one individual? So far, the "switches" which influence animal growth have eluded researchers. Imagine taking your cheek cells and growing multiple copies of you!

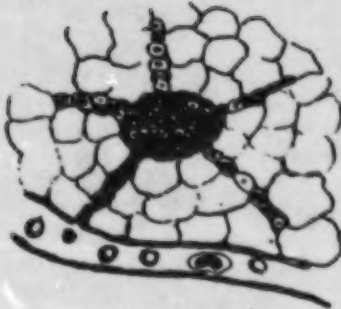
Probably, in the course of your lifetime, you have encountered your share of cuts, bruises, and perhaps broken bones. Your body has produced new cells by the process of mitosis to heal the wound. Some areas of your body heal faster than others, such as your skin heals faster than a broken bone. Others will not heal once you have reached maturity. For instance, damage to hair and nerve cells may result in a permanent injury.

If cell production switches on and off at the wrong times, problems will result. Consider cancer, the disease that in recent years has become a leading killer of humans. Essentially, what happens in cancer is that normal cells begin to divide rapidly and develop abnormally. In some areas of the body, these cells form a mass of cells called a tumor. When a tumor reaches large proportions, it can interfere with and weaken the organ it invades.

Some tumors grow into a group of abnormal cells that remain localized within their normal territory and do not invade the surrounding tissues. These form benign tumors. Warts are examples of benign tumors.

Benign tumor





Malignant Tumor

At other times, the tumor cells divide very rapidly and can spread (metastasize) to other areas or distant regions of the body by way of circulation. These are known as malignant tumors or cancers. Cancer is the name of the constellation where the ancient astronomers observed the stars in the shape of a crab. A crab has a main body with many legs. This is what occurs in a malignant tumor. The cells form a main body and several "legs." It is the "legs" which invade other healthy organs or grow into blood vessels. Here, the force of the blood flow can break off cells. These cells can migrate to new sites especially the capillaries in the liver or the lungs.

Once they have reached new areas they may produce new cells which, in turn, form new tumors. The ability of a cancer to spread to distant sites allows the disease to pass beyond the reach of local surgery.

Cancer research is focused on the factors which switch mitosis on and off. When we learn how to switch the process of mitosis and differentiation on and off, a new era in man's control of life will be opened up. The answers to these and other related questions may still be years away, but the current research efforts are well worth it. And, all this from studying carrots!

INVESTIGATION #15: CELL DIVISION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Carrots, Cloning, and Cancer

1. Imagine you are raising money for the American Cancer Society. A person asked for a donation responds negatively. They do not want their money spent on studying carrots, flies, or worms. How would you respond?
2. In our modern society, it appears that everything causes cancer. Describe two factors implicated in causing cancer.
3. Discuss the pro's or con's of cloning experiments.
4. Burn victims can have skin grafted from one area of the body to the damaged area. How is this possible?

INVESTIGATION #16: REPRODUCTION

Name _____
Section _____ Date _____

INTRODUCTION

The females of each species produce eggs of one kind or another. From these eggs come new individuals. What is necessary for the eggs to develop?

EXPLORATION

Eggs

Observe the eggs and record any differences.

Table 16-1

[illegible]

THE IDEA

What idea do the data allow you to state?

INVESTIGATION #16: REPRODUCTION

EXPANSION OF THE IDEA

Reading: Common Birth Defects

The cells of all organisms contain a fixed number of chromosomes. In normal humans, there are twenty-three pairs or a total of forty-six chromosomes per cell. Important exceptions are the sperm and egg cells. Each contains twenty-three chromosomes, or one member of each pair. At fertilization, each parent provides one sperm or one egg. As sperm and egg fuse, they form a fertilized egg cell with the full chromosome number. It is a miracle that this process works so well most of the time.

However, chromosome errors can occur, particularly during the formation of the egg and sperm cells. As a result, the fertilized egg cell may contain an abnormal number or arrangement of chromosomes. Once such an error occurs, it is repeated in the millions of cells going through mitosis in the growing embryo.

The most common birth defect resulting from an extra chromosome is Down's syndrome or mongolism. The Down's syndrome manifestations include mental retardation and distortions in physical appearances. The possibility of a chromosomal error is known to be higher toward the end of the reproductive years. Examine the table below to see which group of women are at the highest risk.

Maternal Age	Risk of Occurrence
20-30	1:1500
30-35	1:750
35-40	1:600
40-45	1:300
45-up	1:60

All the egg cells that a woman produces throughout her life are present in immature form in her ovaries from the time she is born. As she ages, the chances increase for a mistake during the maturation process prior to its fertilization. Hence, the older woman has a higher risk of having a Down's Syndrome child.

Other birth defects may result from environmental variables. Exposure to certain drugs, radiation, or viruses may cause defects in the developing embryo or fetus. It is important to note that this category of birth defects is the most preventable.

During the first trimester of pregnancy, the process of mitosis occurs rapidly. Growth and differentiation of the tissues of the embryo result. In the first month, the first system to differentiate is the nervous system. Exposure to outside environmental variables may cause damage to this delicate system. During the fifth and sixth weeks of pregnancy, the limb buds begin to differentiate. This was demonstrated tragically in the early 1960's. Pregnant women who took a tranquilizer, thalidomide, at this stage of their pregnancy, eventually gave birth to children missing arms and legs. Exposure to the German measles virus (Rubella) during pregnancy is known to produce children with a wide range of birth defects. The conclusion is that a pregnant woman should avoid exposure to any drugs including alcohol, aspirin, and even caffeine without her doctor's consent. To insure a healthy baby, good prenatal care should begin as soon as a woman suspects she is pregnant.

INVESTIGATION #16: REPRODUCTION

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Common Birth Defects

1. A young woman discovers that she is pregnant. She insists that she will not need a doctor until the baby is born. How would you respond to her?

2. Why are women encouraged not to smoke during a pregnancy?

3. Why is the first trimester of pregnancy the most important?

INVESTIGATION #17: INHERITANCE

Name _____
Subject _____ Date _____

INTRODUCTION

Hair and eye color, handedness, and tall or short are characteristics that vary from person to person. Did you ever wonder why you resemble your parents or another relative?

EXPLORATION

Characteristics

1. Complete Table 17-1 by checking the characteristics you have.
2. Use numbers to indicate how many class members have each characteristic. Add these to Table 17-1.
3. Complete Table 17-1 with the name of each relative you test and the characteristics of each.

Table 17-1

Characteristic	You	Class				
Tongue Roller						
Non-tongue roller						
Curly hair						
Straight hair						
Blue eyes						
Brown/green eyes						
Left-handed						
Right-handed						
Earlobes attached						
Earlobes unattached						
PTC taster						
PTC non-taster						

INVESTIGATION #17: INHERITANCE

Name _____
Section _____ Date _____

THE IDEA

1. Which characteristic was most common among the class members?

2. How many students in your class had the characteristics you named on Table 17-1 in common with their parents, siblings, or grandparents?

3. What idea do the data allow you to state about characteristics?

INVESTIGATION #17: INHERITANCE

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Punnett Squares

Crosses of many different characteristics can be done on a Punnett square. The most common symbols used are a capital letter for the dominant gene of the trait and a lower case letter for the recessive gene, for example, B=Brown, b=blue eyes. BB and bb would be homozygous genotypes. Bb would be the heterozygous genotype, the phenotype would be brown eyes.

- Write the genotype for a person homozygous for blue eyes. _____
- Write the genotype for a person heterozygous for brown eyes. _____
- Fill in the possible offspring in the cross between two people heterozygous for brown eyes.

	B	b
B	_____	_____
b	_____	_____

- What percent of the above cross has the genotype
BB? _____
Bb? _____
bb? _____
- What percent of the offspring have the phenotype for Brown eyes? _____ Blue eyes? _____
- Why are the percentages for the genotype and the phenotype are different?
- Cross a homozygous curly-haired male with a homozygous straight-haired female. C = curly hair c = straight hair

_____	_____ % homozygous curly
_____	_____ % homozygous
_____	_____ % heterozygous

INVESTIGATION #17: INHERITANCE

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Blood Typing

1. To determine whether your blood is Type A, B, or O. Clean and dry two slides. Make two circles on the first slide and label them ANTI-A and ANTI-B. Use a glass marking pencil to draw the circles. Place a drop of the corresponding anti-serum inside each circle. (A drop of Anti-A serum goes onto the slide with the circle labeled anti-A and the same with Anti-B.) Be careful not to get them mixed up.
2. Obtain a drop of blood as directed by the teacher. With a toothpick, place a half of a drop of blood in each of the circles and stir the blood into the anti-serum. Be careful not to mix sera. Use a clean toothpick for each drop.
3. Examine for agglutination (clumping) within sixty seconds. If any agglutination occurs, it will appear as a visible clumping of cells in the drop of anti-serum. Record your blood type on Table 17-3.
4. To determine your Rh factor, make a circle on a slide and label it Anti-Rh. Add anti-serum and a drop of blood to the circle. Use a clean toothpick to stir the blood and serum. Warm the slide gently over a light bulb for up to five minutes. Rock the slide gently and watch for agglutination. If clumping occurs you are Rh+, if not you may be Rh-.

Table 17-3

Blood Type	Yours	Number in Class	% in Class	% in U. S.
A				
B				
AB				
O				
Rh+				
Rh-				

INVESTIGATION #17: INHERITANCE

EXPANSION OF THE IDEA

Reading: The Genetic Chance

You have seen several obvious characteristics which were passed to you from your parents. We are more like our parents than we may realize. Hair, skin, and eye color are among the obvious traits we inherit. Have you ever thought about inheriting tongue-rolling? What about the hidden or unobservable characteristics, especially the ones that cause serious disorders?

Most couples look forward to the birth of a baby. Whether it is a boy or a girl is not important as long as it is healthy. Janet and Bob's first child, a boy, appeared normal at birth but at six months of age, the baby began to "unlearn" all he had learned to date. He lay listless and even lost his cute smile. Janet and Bob provided the best for for him emotionally, medically, and financially. However, he continued to deteriorate both mentally and physically. Medical testing revealed a serious genetic defect. He died at the age of four.

Janet and Bob desperately wanted another child; but, would another baby be normal and healthy? What caused the defect? Might another child inherit the same disease? What should they do?

Only a few years ago, this couple would have faced a sad dilemma: should they risk having another child? Their questions would remain unanswered until the second child was born. Times have changed. Janet and Bob recently fulfilled their wish for a second child. They were confident in advance that there was not a risk of the same problem. How was this confidence made possible?

This success story and others are the results of recent discoveries in medical genetics. In the case of couples such as Janet and Bob, the assistance of genetic counseling can provide answers. Genetic counseling is concerned with all factors causing birth defects. A counselor first must determine whether the defect in question is transmitted by the genes or the chromosomes passed from parent to child; or, is it due to an abnormal chromosome number, an infection, or other influences during life in the womb?

One possible cause is due to a defective gene. Over the years, scientists have observed that certain medical disorders seem to "run in families." Other studies have revealed that certain ethnic groups are at a higher risk than others for unknown reasons. Often, screening tests which require a small sample of blood or urine can detect whether a person is a carrier of a genetic disorder. Even when a disorder is diagnosed as being inherited, it does not mean that another child born to the same parents will have the same problems. There may be a high, moderate, or low risk depending upon how the defective trait is inherited.

An examination of one common birth defect will help us to figure the chances or odds. Cystic fibrosis is the most common inherited disease among white Americans. It causes a thick mucus to form in the lungs and in the pancreas. The mucus interferes with breathing and digestion. The presence of one single, dominant gene (N) and one recessive gene (n) will still produce a normal child (Nn). A person must inherit two recessive genes (nn) to develop the disease. The problem may occur if two carriers have an offspring.

What are the chances that two carriers (Nn + Nn) will produce a child with cystic fibrosis. Examine Table 17-4 which illustrates a case of recessive inheritance. The key is N = normal gene, n = defective gene.

Table 17-4

	Carrier	Carrier									
parents	Nn	Nn									
possible gametes	$\begin{array}{c} \diagup \quad \diagdown \\ N \quad n \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ N \quad n \end{array}$									
	<table> <tr> <td></td> <td>N</td> <td>n</td> </tr> <tr> <td>N</td> <td>NN</td> <td>Nn</td> </tr> <tr> <td>n</td> <td>Nn</td> <td>nn</td> </tr> </table>		N	n	N	NN	Nn	n	Nn	nn	Genotype Ratio
	N	n									
N	NN	Nn									
n	Nn	nn									
possible offspring (F1 generation)		25% normal (NN) 50% carriers (Nn) 25% having the disease (nn)									

Although many may think that a 25 percent (or one-in-four chance) means that the next three offspring are not endangered, this is not true. The risk is the same for each child.

Let's examine the underlying premise of a genetic defect. Inborn characteristics, for example eye color, hair color, or the production of essential enzymes governing the digestion of foods are controlled by the action of one or more pairs of genes. These genes are contained within the chromosomes of the nucleus of all cells. There are literally thousands of genes within each chromosome. Among this vast number, a few are likely to be abnormal. Thus each of us carries defective genes. However, only rarely do two parents carry the same defective genes. Fortunately, the normal gene for a given trait transmitted at fertilization by one parent usually overshadows the harmful effects of the defective gene transmitted by the other parent. Despite the presence of one defective gene in the child no genetic disease results. The child will only be a carrier of the defect. If the child inherits a faulty gene from each parent, then the disease will result.

If genetic defects are suspected, an extensive family history must be developed by a genetic counselor. The family history is judged to determine if an individual is a carrier.

Other serious disorders which have been found to be recessively inherited include sickle-cell anemia, PKU (a severe form of mental retardation due to an enzyme deficiency), and Tay-Sachs disease (another enzyme deficiency which destroys nerve cells). Some disorders may be due to a case of dominant inheritance. In his late thirties, Woody Guthrie, the popular American folk singer, suffered from dramatic changes in personality and memory lapses. His mother had exhibited the same symptoms. At that time, she was declared insane and locked up for life in a mental hospital. However, Woody was diagnosed as having Huntington's disease, a dreaded incurable form of insanity. This is a human genetic disease carried by a dominant gene. Symptoms of Huntington's disease do not appear until the age of thirty-five or later. The victim may have passed along the disorder to their children by this time. Presently, the disorder cannot be detected in children. Persons afflicted appear normal until their late thirties or forties. Then they begin to develop the symptoms which lead to a progressive deterioration of the nervous system.

An examination of Table 17-3 will reveal how this disorder can be inherited. The key for the table illustrating dominant inheritance is H = gene for Huntington's disease, h = normal gene.

Table 17-5

	Huntington's Disease	Normal
parents	$\begin{array}{c} Hh \\ \diagup \quad \diagdown \\ H \quad h \end{array}$	$\begin{array}{c} hh \\ \diagup \quad \diagdown \\ h \quad h \end{array}$
possible gametes		
	$\begin{array}{cc} H & h \\ \hline h & Hh \mid hh \\ \hline h & Hh \mid hh \\ \hline h & \end{array}$	Phenotypic ratio: 50% Huntington's disease 50% normal

In the case of Janet and Bob, they both were found to be carriers of a recessively inherited disease. Detection of this particular disorder in an unborn child may be accomplished through a procedure known as amniocentesis. The relatively safe procedure helps to detect 80% of the serious genetic disorders early in pregnancy. A sample of amniotic fluid is extracted from the sac around the baby. Cells shed by the fetus may be found there. Once withdrawn, the cells can be grown and tested for chromosome abnormalities such as Down's Syndrome or biochemical deficiencies, such as those resulting from many of the cases of recessive inheritance. Janet and Bob's second baby was found to be normal.

Hopefully prenatal diagnosis of genetic defects will improve and prenatal treatment begun. The advances we have seen to date are certainly encouraging.

INVESTIGATION #17: INHERITANCE

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: The Genetic Chance

PKU (phenylketonuria) is an inherited condition of mental retardation. However, early diagnosis is essential since this disease is treatable. Homozygous recessive genes fail to make a necessary enzyme. Victims cannot digest proteins containing a certain amino acid. Therefore, victims are given a diet low in this amino acid. How the high levels of this amino acid bring about mental retardation is not yet known.

1. What are the chances of two carriers of PKU having a child who has the deficiency? The key for Table 17-6 is P = normal gene, p = defective gene.

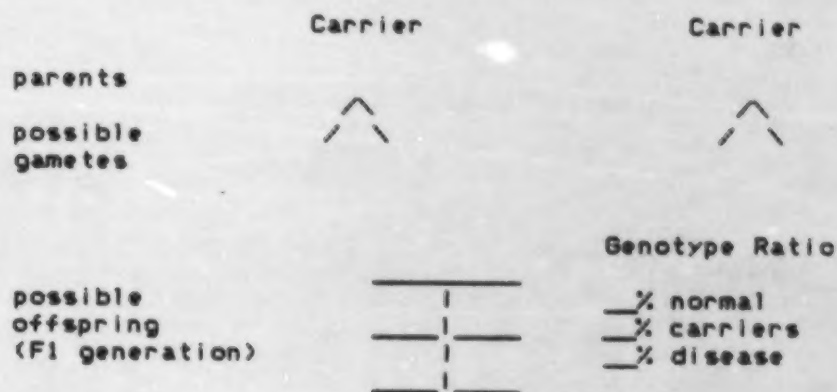
Table 17-6

	Carrier	Carrier								
parents										
possible gametes	$\begin{array}{c} \diagup \\ \diagdown \end{array}$	$\begin{array}{c} \diagup \\ \diagdown \end{array}$								
possible offspring (F1 generation)	<table> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> </table>									Genotypic ratios: ☐ % normal ☐ % carriers ☐ % having the defect

2. Infants are now screened at birth for PKU because of laws in forty-eight states. Is this screening an invasion of privacy? State your reasons.

While at play, a young black child tires easily, becomes pale, and complains of pains in the arms, legs, back, and abdomen. His appetite is poor. A chest cold brings on a crisis, a period when pain and other symptoms are severe. A doctor examines a blood sample which reveals abnormally-shaped red blood cells. Instead of being disc-shaped, they are shaped like a crescent or sickle. Sickle-cell anemia is another example of a recessively inherited disorder.

3. If a man with sickle-cell anemia marries a woman who is a carrier, what are the chances that a child will inherit the disease? Key for Table 17-7 is S = normal gene, s = defective gene.



INVESTIGATION #18: HOMEOSTASIS

Name _____
Section _____ Date _____

INTRODUCTION

Organisms live in an ever-changing environment. How do organisms adjust to the changes in their environment?

EXPLORATION

Body Thermostats

Table 18-1

	Temperatures	
	Oral	Skin
Measure and record both your oral and skin temperatures.		
Place your hand in cold water for two minutes. Immediately measure and record your temperatures.		
Measure your oral and skin temperature every minute until both have returned to "normal". Record how many minutes it took to return to normal (recovery time).		
Measure and record both your oral and skin temperatures.		
Exercise for 5 minutes. Measure and record both your oral and skin temperature.		
Measure your oral and skin temperatures every minute until both have returned to "normal". Record how many minutes it took to return to "normal" (recovery time).		

1. Which temperature, oral or skin, showed the greatest change?
2. What other changes did you observe after exercising for five minutes?

INVESTIGATION #18: HOMEOSTASIS

Name _____
Section _____ Date _____

EXPLORATION

Go back through your previous investigations to complete Table 18-2.

Table 18-2
Changing Conditions

Investigation	Changing Conditions	Describe what Happened
Organism #1	Fish response to temperature	
	Worm response to light	
Ecosystem #6	Microecosystem response to environmental variables change	
Circulation #9	Heart rate after exercise	
	Recovery time of heart rate	
Breathing #11	Breathing rate after exercise	
	Breathing rate after bag breathing	
Senses #13	Eye Responses to light	
	Knee response to pressure	
Growth #15	Animal being cut	
Homeostasis #18	Skin and body Temperature response to hot water	
	Skin and body temperature response to exercise	

INVESTIGATION #18: HOMEOSTASIS

Name _____
Section _____ Date _____

THE IDEA

1. What happened to your body temperature after you placed your arm in cold water? after you exercised?
2. Why do you think the breathing rate, heart rate, and skin temperature changed after exercising?
3. Why do you think that after exercising, the recovery time of the heart rate and breathing rate varied from person to person?
4. Why do you think the breathing rate changed after breathing into a bag?
5. What do all of the examples in Table 18-2 have in common?
6. What idea do the data allow you to state about an organism's response to change?

INVESTIGATION #18: HOMEOSTASIS

EXPANSION OF THE IDEA

Reading: The Heat is On

A turtle slides from a log into the water. An American alligator glides from the shallows of a swamp into deeper water. A prairie dog seeks the shadows of its burrow to escape the white-hot glare of the summer sun.

Each animal carries within its body a tiny transmitter that sends out blips and beeps indicating changes in heart rate, blood flow and body temperature. The encoded messages are received by biologists equipped with special devices that measure body changes which occur within animals as they seek to keep cool in hot weather.

The study of how animals regulate their body temperatures has given biologists a great deal of information about the ways in which animals react to heat stress. These vary from species to species, but all rely on the same basic principles.

One reaction people have to heat is to sweat. Another is to go into an air-conditioned building. Sweating is a physiological reaction and seeking shelter a behavioral one. Physiological and behavioral responses are the two means by which all organisms adjust to changes in their environment.

Sweating is the basis for evaporative cooling. Moisture exuded by sweat glands accumulates on the skin and the skin is cooled as the moisture evaporates. Sweating is not the only way animals employ evaporative cooling. Many animals pant when hot, using their moist lungs as evaporative radiators to expel excess heat.

Mammals are usually referred to as warm-blooded animals. Scientists call such animals endotherms, because their source of heat is internal, coming from metabolism within the body. Cold-blooded animals, on the other hand, are called ectotherms, because their heat source is outside their bodies.

Yet, even ectotherms can regulate their body temperatures to some extent. Turtles, including the three-toed and the ornate box turtles use evaporative cooling when the heat is too much for them. The three-toed box turtle froths at the mouth and nostrils when warm, giving off excess heat through evaporation of the moisture.

The American alligator lies with its elongated snout wide open, cooling by the evaporation of moisture from its mouth. Alligators also seek water when too warm. When temperatures are especially high, they sink to the depths of their ponds, where they may dig holes in the muddy bottom to create deeper, cooler waters.

The spiny soft-shell turtle, can cool itself by evaporating water through its shell. Although reptiles are thought of as more "water tight" than the moist-skinned amphibians, the soft-shell turtle can evaporate water at a greater rate than some salamanders. Such rapid water loss can present another problem, dehydration. If the turtle cannot reach water on hot days, it will eventually dry out and die.

Striking a balance between saving water and keeping cool is especially important to animals that do not have access to standing water. The prairie dog, for example, lives in arid regions and cannot afford to lose large amounts of body moisture to cool off. Consequently, the prairie dog has some behavioral responses which help it keep cool.

During the hottest part of each summer day, the little dogs stay in their burrows, avoiding the intense rays of the sun. Their burrows stay fairly cool and are even designed to direct air flow into their depths.

The prairie dog's problems with maintaining body moisture during the hottest time of the year are overcome somewhat by his diet. Green grasses abound around dog towns and are eaten by the prairie dogs, which can utilize water stored in the plant cells. In the plants they eat, prairie dogs have a virtual lake surrounding them.

The real champ at keeping cool under arid conditions is the kangaroo rat. Found in dry desert areas, this gerbil-like creature can survive without drinking water. By restricting its activity to the nighttime, when ground and air temperatures are cool, the rat diminishes the amount of cooling it has to do. During the day, it keeps to its burrow, where humidity is high, another factor in limiting water loss.

Kangaroo rats have several physiological adaptations which permit them to keep cool without dehydration. Water is saved by the kidneys, which are so good at extracting water for storage in the body that the animal can drink seawater and survive.

Although the rats stay in burrows and avoid the hot hours, if they suffer heat stress, they will use their body fluids in evaporative cooling by salivating and licking their fur.

Evaporation of water is not the only means for cooling. Blood flow is important to both the heating and cooling of animals. In jackrabbits, the large ears are latticed with a web of blood vessels and serve in keeping the animals cool. Body heat is carried in the blood to the ears, where it is radiated from the body through the thin tissues of the blood vessels and skin.

Blood flow also is of importance to the heat regulation of snakes. In some snakes, a system of vessels cools blood going to the head. This maintains the head and sensitive brain tissue at a lower temperature than that of the rest of the body during periods of overheating.

Behavioral responses help many animals maintain body temperatures at fairly steady levels. Most amphibians are active only at night, avoiding the hot sunshine which would suck the moisture from their bodies. Snakes are sensitive to heat, and some rattlesnakes will die if their body temperatures become as warm as our own average of 98.6 degrees Fahrenheit.

Collared lizards can be seen sunning on rocks in some parts of the country in the morning. After the cool night has ended, the lizards warm up by basking in the sun. When they've had enough, they seek shade where they can avoid reaching the high temperatures that will kill them.

Birds do not have the lizard's luxury of being able to survive at rather widely ranging body temperatures and must have a mechanism for rapid cooling. As a behavioral response, birds seek shade. They also evaporate water from their respiratory systems, using "gular flutter," a rapid pumping of the throat muscles that exchanges the warm air in their airsacs with cooler fresh outside air.

Young birds in many cases do not become truly endothermic until some time after birth. In the early days of life, they still are much at the mercy of the environment. To keep nestlings cool, adult birds shade them with their wings. In some cases, adults will wet their breast feathers before brooding nestlings.

The stress of prolonged migration flights causes birds to heat up. To offset this, birds will seek greater altitude, where the air is cooler.

Sometimes an adaptation that helps an animal during one season's thermal stress would be a hindrance at another time of year. Crows cluster during the winter, sharing body warmth and raising the temperature around them. If they did this in summer, they would only increase their problems of keeping cool. During summer, however, crows nest singly, avoiding such accumulation of body heat.

Whether an animal is an endotherm or an ectotherm, temperature regulation requires coordination between parts of the brain and the systems for circulation, respiration and excretion. Nerve cells, kidneys, blood vessels, heart, lungs, muscles, all have to function properly if an animal is to survive periods of overheating.

Why must organisms maintain internal conditions within certain limits? Why can't temperatures of 150 to 200 degrees Fahrenheit be tolerated? The answers can be found through an understanding of the kinds of chemical processes required to carry on life. The processes of cell metabolism cannot occur if the internal temperature is too high or too low. Other factors such as water, salt, or glucose concentration also must be maintained at certain levels.

In order to maintain stable internal conditions, organisms have developed the ability to undergo physiological changes (such as sweating) in response to environmental changes. Behavioral responses are also involved in an organism's attempt to keep internal conditions stable. Responding to changes in the environment either by regulating chemical processes or by behavior which keep the internal conditions stable, is known as homeostasis.

The next time you step outside into the summer heat, consider your body's response. Blood vessels are dilating, sweat glands opening, adjustments being made for water loss and loss of salts. Eventually your mouth dries, an indication that you need more water to keep your biological machine running. When the heat becomes too much for you, and your pupils have constricted as far as they can in the bright light, you move to the shady side of the street—or faint.

Meanwhile, elsewhere, a turtle is sliding into the cool waters of a lake, an alligator is digging deeper, a prairie dog moves into his burrow. All following their own intricate plan for surviving in the best of all possible worlds, where the sun we cannot live without is sometimes too hot to live with.

Excerpted from a July, 1979 article by Roger DiSilvestro in "Outdoor Oklahoma"

INVESTIGATION #18: HOMEOSTASIS

Name _____
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: The Heat is On

1. In what two ways do animals regulate the internal temperature of their body?
2. Describe one example of temperature regulation that involves a physiological change.
3. Describe one example of another way (besides using physiological changes) animals regulate their internal conditions.
4. List three internal factors which must be constantly kept stable.